# THE PROBLEM OF MAN'S ANTIQUITY

## An Historical Survey

BY

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CONTENTS



SYNOPSIS


Establishment of man's high antiquity depended on finding undoubted artifacts in deposits of known geological age, and human bones fossilized with extinct animals : discoveries by Boucher de Perthes in Somme gravels and by Schmerling in Belgian caves. Stratified rocks first divided into three age-groups. Lyell subdivided the Tertiary era into five periods on faunal evidence. Living species and signs of man predominated in Post-Pliocene deposits constituting Quaternary era with its ice age. Palaeolithic cultural stage, earlier Quaternary (Pleistocene) ; question of whether any artifacts occur in Tertiary deposits.

Organic content of human bones from Neanderthal and Aurignac cited as dating evidence. Neanderthal skull compared with that from Gibraltar : evidence of an extinct species of man. Moulin-Quignon jaw not fossil. Remains of apes described in early nineteenth century from European Miocene : but idea persisted that man in present form already existed, hence modern skeletons unearthed from Pliocene deposits then uncritically accepted as fossils. Cro-Magnon cave yielded fossil *Homo sapiens*, Late Pleistocene fauna and Upper Palaeolithic industry.

French caves and open sites provided sequences of Palaeolithic industries and faunal stages which served as frameworks for relative dating of fossil man in Europe. Interest shifted to tropics : remains of early Pleistocene *Pithecanthropus* found in Java ; jaw of contemporaneous hominid in Mauer Sands, fauna eventually ranked as basal Middle Pleistocene.

Finally four orders of relative dating (R1, R2, R3, R4) and four orders of " absolute " (chronometric) dating (A1, A2, A3, A4) are defined and applied to the classic fossil hominids

## I. ANTIQUITY OF MAN: HISTORICAL BACKGROUND

THE appearance of Darwin's *Origin of Species* in 1859 dramatically focused attention on the whole problem of the origin of living things including man himself. In his autobiography Darwin has recorded that already in the year 1837 or 1838, when he first became convinced that species were mutable productions, he could not avoid the belief that man must come under the same general law. He continued as follows:

"Although in the *Origin of Species*, the derivation of any particular species is never discussed, yet I thought it best, in order that no honourable man should accuse me of concealing my views, to add that by the work in question 'light would be thrown on the origin of man and his history'. It would have been useless and injurious to the success of the book to have paraded without giving any evidence my conviction with respect to his origin."

The first step towards working out the application of his theory to man was to collect the facts, and this he did in preparing his book on *The Descent of Man* (1871). Darwin there stated that it was the establishment of the high antiquity of man that was the indispensable basis for the understanding of his origin; and for the demonstration of this he was indebted to the geologist Sir Charles Lyell, who assembled the facts then available in *The Geological Evidence of the Antiquity of Man* (1863), and to the prehistorian Sir John Lubbock (afterwards Lord Avebury) whose book on *Prehistoric Times* appeared in 1865.

Establishing the antiquity of man depended on two sorts of evidence: recognizable works of man, such as deliberately shaped stones (artifacts), found in geologically datable deposits; and fossilized human remains associated with extinct animals.


FIGS. 1–3. Selection of "ceraunia" figured by Mercati (d. 1593). "Most men" he said "believe that ceraunia are produced by lightning": but he considered they "have been broken from very hard flints . . . in the days before iron was used for the follies of war". Fig. 1, polished stone axe-head (Neolithic). Fig. 2, blade tool (Upper Palaeolithic ?). Fig. 3, tanged arrowhead (Bronze Age). All × ½ nat. size.

The conception that man had a long unrecorded past entered very few minds before the middle of the last century, although the seeds of the idea had been sown by a few men far ahead of their time in earlier centuries, for example Michèle Mercati who, in the second half of the 16th century,[1] concluded that the stones popularly called ceraunia (thunderbolts) were really stone implements made before men had iron (Text-figs. 1–3), the Frenchman Isaac de la Peyrère, whose book *Primi Homines ante Admum* (claiming that ceraunia were the work of a pre-Adamite race of man) was publicly burnt in Paris in 1655 ; and the English archaeologist John Frere whose discovery of flint implements in brickearths at Hoxne in Suffolk (Text-fig. 4) led him to infer in 1797[2] that they had been " used by a people who had not the use of

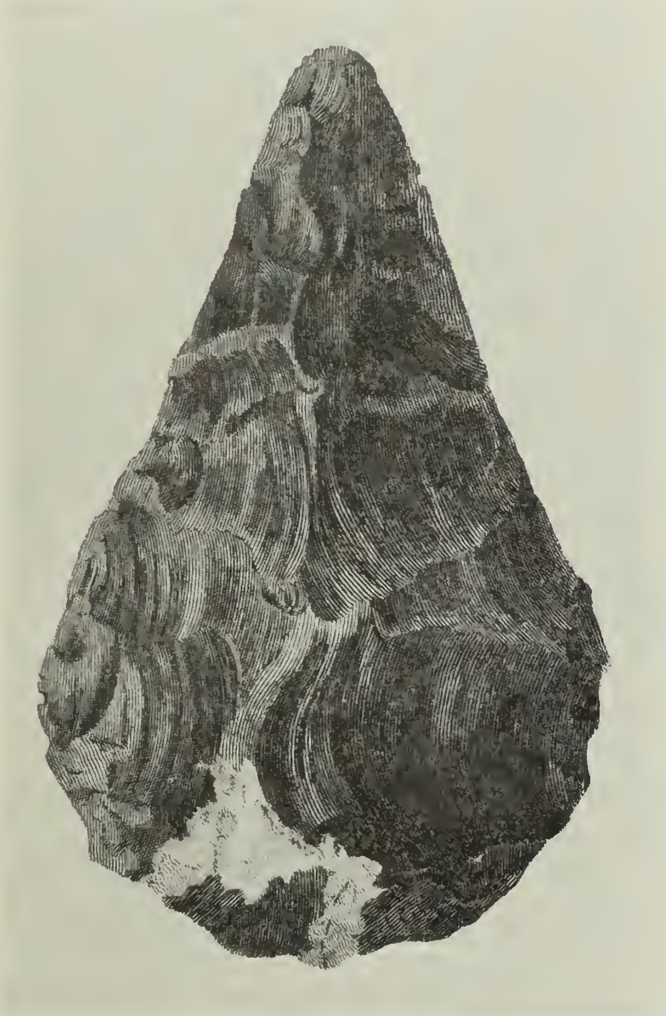


FIG. 4. Flint hand-axe (Lower Palaeolithic) from deposit containing bones of extinct animals at Hoxne, Suffolk. *After J. Frere*, 1797. Nat. size. Ashmolean Museum, Oxford.

metals", and belonged "to a very ancient period indeed, even before that of the present world".

The first record of the other class of evidence, association of human bones with extinct animals, was apparently made by Johann Friedrich Esper, who in 1771 discovered in the Gailenreuth caves near Bamberg some human bones associated with cave-bear. In his report on the discovery, published in 1774, he asked this question about the human bones : "Did they belong to a Druid or to an Antediluvian or to a Mortal Man of more recent times?"—and concludes : "I dare not presume without any sufficient reason these human members to be of the same age as the other animal petrifactions. They must have got there by chance together with them."[3]

Esper's scientific caution was admirable, for he hinted clearly enough that he had begun to doubt the current orthodoxy. Not so Professor Johann Scheuchzer of Zürich, who some forty years earlier (in 1731) had described some fossil bones embedded in a layer of shale from Oeningen in Baden as "the bony skeleton of one of those infamous men whose sins brought upon the world the dire misfortune of the deluge". He labelled an illustration of this specimen "*Homo diluvii testis*".[4] A century later the great French naturalist Cuvier identified the remains as those of an extinct salamander, which was named *Andrias scheuchzeri*—it is of Miocene age, that is to say about 20 million years old.

Cuvier was opposed to the idea of the great antiquity of man. He was one of the leading Catastrophists, believing that the fossil records could only be explained by a series of creations[5] alternating with catastrophic floods of which the Noachian was the most recent, and he denied that there was any acceptable evidence for the existence of fossilized remains of man. Commenting on some human bones alleged to have been found with remains of diluvial animals in the Rhine Valley, he wrote in 1823 : "All the evidence leads us to believe that the human species did not exist at all in the countries where the fossil bones were found, at the period of the upheavals which buried them".

In his work on *Reliquiae Diluvianae* (1823), the Rev. William Buckland, Professor of Geology in the University of Oxford, and a follower of Cuvier, explained the use of the term diluvium for those superficial deposits, gravels, loams and the like produced by the "last great convulsion that has affected our planet". He said that wherever human remains had been discovered in Europe with bones of antediluvian animals, attendant circumstances indicated them to be of *post*diluvian origin ; although he admitted that theoretically human remains might be expected in the diluvium of central Asia—the "cradle of the human race". He judged that the Deluge was of short duration and took place not more than 6,000 years ago. As one of the authors of the Bridgewater Treatises written to illustrate Paley's *Natural Theology* Buckland was hampered by the conception there endorsed that the world had been created about 4004 B.C. He expostulated with John Hunter over his conclusion (published in 1794) that the animal bones in the Gailenreuth caves accumulated through these being occupied by wild beasts during "many thousands of years" (an opinion grounded on the different degrees of preservation of the bones). According to Buckland this was a grossly excessive estimate—he thought that Hunter should have said many *hundreds* of years.

The tradition of the universal Deluge undoubtedly hindered the progress of geological knowledge for a number of years, but the more enlightened diluvialists eventually saw the impossibility of explaining all the facts in terms of a single flood. Buckland admitted that there must have been many catastrophes besides the Noachian Deluge. The difficulties in which he found himself, inspired the couplet written by one of his ecclesiastical friends :

*Some doubts were once expressed about the Flood ;*
*Buckland arose, and all was clear as . . . mud.*

In later life Dean Buckland modified his diluvial theory ; and after accepting Agassiz's demonstration of the action of ice he admitted that some of the deposits in Britain which had been attributed to the deluges were probably the outcome of glacial action.

Just as a revolution in biological thought was brought about by the publication of Darwin's theory of the origin of species by natural selection, so geological thought was revolutionized by Lyell's *Principles of Geology* (1830–1833) which marshalled an immense array of observations indicating that the present is the key to the past. This idea of " uniformitarianism " in the physical world was obviously much in line with the principles of continuity and gradual development in the biological sphere expressed by Darwin's theory : just as on the other hand " catastrophism " marched with the idea of a series of special creations. Uniformitarianism did not imply that conditions or processes in past ages were always identical with those in the present, but that they were of the same general character, differing only in distribution and degree. Thus, observations on the action of glaciers in the Alps when applied to the interpretation of certain types of deposit (*Drift*) in Britain led to the inference that this country had been affected by an Ice Age. Buckland, in contrast, had remarked in 1823 (p. 227) on " the total impossibility of referring any of these appearances to the effect of ancient or modern rivers, or any other cause, that are now or appear ever to have been in action, since the retreat of the diluvian waters ".

At numerous sites in Europe during the first half of the nineteenth century, human bones and artifacts were found with remains of extinct animals, and were being claimed by an unorthodox minority of investigators as indicating man's great antiquity. These finds were not, however, widely accepted as genuine associations so long as the climate of scientific opinion was dominated by creationist or diluvialist doctrines. Some of the claims, particularly those relating to human skeletons, may have been erroneous, but others were genuine enough and were recognized as such by a few unprejudiced minds. In 1823 Buckland himself discovered a human skeleton (which we now know to have been that of a man of the Ice Age) under a covering of red ochre in Goat's Hole, Paviland, in South Wales (Text-fig. 5), but he assumed that it was the skeleton of a British woman dating from about the time of the Roman Conquest. He interpreted the numerous artifacts of mammoth ivory which were in contact with the ribs of this " Red Lady of

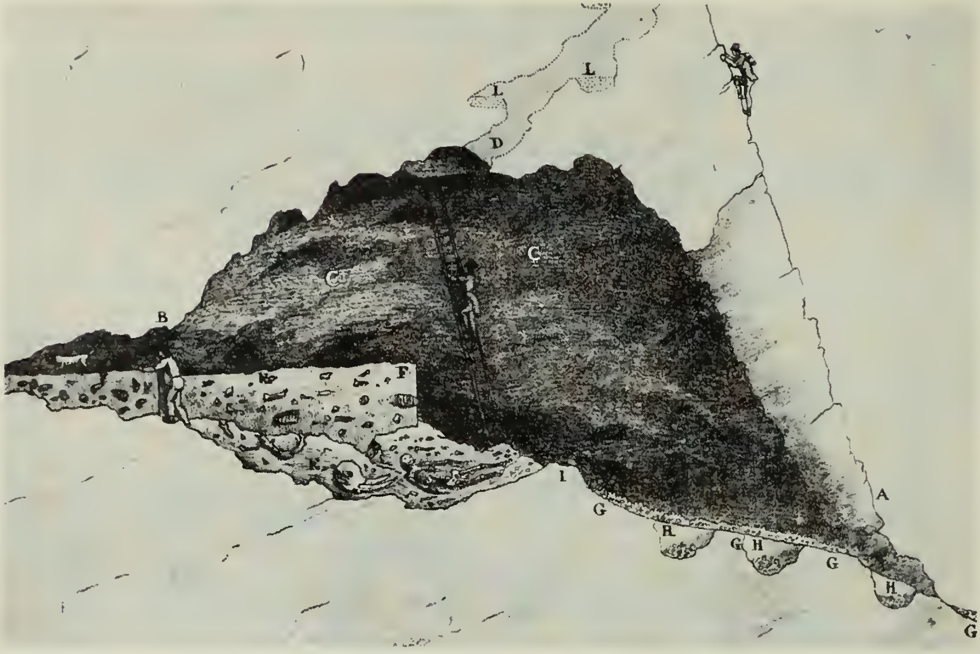



FIG. 5. Goat's Hole, Paviland. *After Buckland*, 1823 The human skeleton is shown as lying in a cavity excavated into the deposits containing remains of mammoth (E, F).

Paviland " as indicating that her kinsmen dug up the antediluvian elephant tusks from the floor of the cave and utilised this fossil ivory for making ornaments. Apparently it did not occur to Buckland that the human skeleton and the ivory might have been contemporaneous.

Early discoveries of this kind indicating man's great antiquity remained generally unaccepted for a quarter of a century or more. One of the least prejudiced pioneers in this field of investigation was a Catholic priest, Father J. McEnery, who began digging in Kent's Cavern, Torquay, in 1825 (following excavations carried out in the previous year by antiquarians seeking for evidence that the cave had been used as a Temple of Mithras). Already by 1829 McEnery had found flint implements associated with fossilized bones of rhinoceros and other antediluvian animals below an unbroken floor of stalagmite or dripstone in this cave. To the discoverer these finds demonstrated quite clearly that man had been coeval with animals that had since died out, in some very remote period of time. He did not convince many of those with whom he discussed the finds, but he patiently continued excavating for some fifteen years. While preparing an account of his work for publication he corresponded with Dean Buckland, who expressed the view that McEnery was surely misinterpreting the evidence. Most probably, the Dean argued, the Ancient British people had dug holes for ovens in the stalagmite floor of the cave, and their flint implements had worked down through these into the underlying antediluvian deposits. McEnery was so discouraged that he abandoned the idea of publishing his manuscript, largely it is said out of deference to Buckland's views. Fortunately his manuscripts were recovered and published posthumously.[6] Meanwhile precisely similar discoveries were being reported on the Continent.

The first excavations in search of fossil bones in the limestone caves of the Midi (Southern France) had been made by M. Jouannet as early as 1810,[7] and explorations were continued there in the late eighteen twenties and early thirties by M. Tournal (working mainly in the famous Grotte de Bize in the Aude department) and by several other naturalists. These pioneer investigators found human bones associated with the remains of animals now extinct (at least in that region) such as cave-bear, hyena, reindeer and rhinoceros. Although one of Tournal's collaborators insisted that the human bones found in the Grotte de Bize were in the same chemical condition as the accompanying mammalian bones, there remained doubts about their antiquity in the minds of many because fragments of pottery were said to have occurred in the same layer, suggesting that there had been an intermixture of materials of more than one age. However, Tournal's eventual discovery of extinct animal bones bearing ancient marks of cutting tools appeared to be proof of man's contemporaneity with the extinct fauna at Grotte de Bize (Text-fig. 6), whatever

FIG. 6. Reindeer antler incised by man, from Grotte de Bize (Aude). *After Cartailhac.* Slightly reduced.

the age of the particular human bones found in the deposit might be. Tournal observed that the fossil animal bones could not have been washed into the cave by a catastrophic flood as the diluvialists argued, because many of the remains were disposed in such a way that they could only have been introduced gradually with the enveloping materials in course of successive periods. In other words, Tournal noted that the bone-bearing deposit was stratified.

Stimulated by the discoveries made by the spelaeologists in the Midi, Dr. P. C. Schmerling, anatomist in the University of Liège, began exploring the limestone caves which border the river Meuse not far from that city. His remarkable investigations included reconnaissance of nearly forty caves and extensive excavations in several of them. The majority of the caves had never been explored before, and Schmerling found that their floors were covered by unbroken layers of stalagmite. His excavations revealed underlying deposits of cave-earth, breccia and stream-gravel containing fragmentary skeletons of various extinct animals, including rhinoceros and mammoth, as well as others apparently coeval with them but still extant, such as wolf and wild boar. In four of the caves Schmerling found human remains, and he noted that these were in the same state of preservation as the ancient animal bones with which they were closely associated. His observations on the chemical and physical condition of the bones are much more precise than those of most of the cave excavators of later years. He pointed out that some of the human bones were found in a stream-worn condition, so there could be no question that they had been intentionally buried in the cave. There could be no doubt, he said, " that the human bones were buried at the same time and by the same causes as the other extinct species ".[8] He also found scattered through these bone-bearing deposits flint implements and worked pieces of bone, leading him to remark : " Even if we had not found human bones in circumstances strongly supporting the assumption that they belonged to the antediluvian period, proof would have been furnished by the worked bones and shaped flints ".

In the most famous of the caves explored by Schmerling, the Grotte d'Engis, on the left bank of the Meuse, about eight miles south-west of Liège, he found the remains of three human individuals. They included a child's skull Engis I embedded close to a mammoth tooth, and the skull of an adult (Text-fig. 7) Engis II which was five feet deep in breccia containing bones of horse, reindeer and rhinoceros.

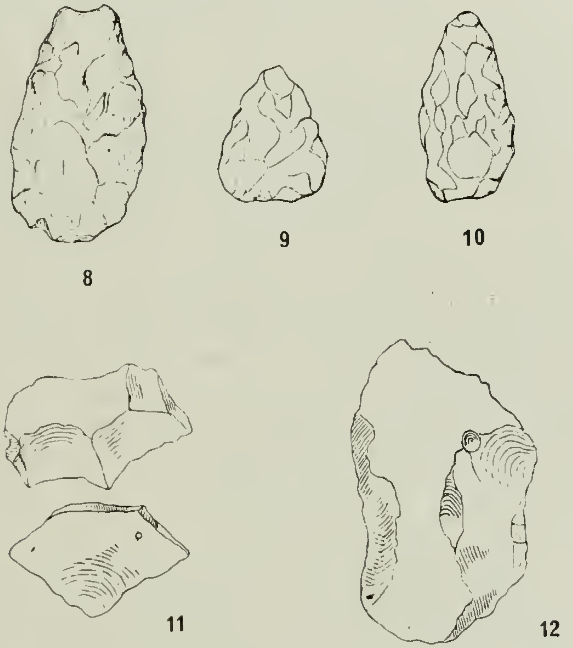
Fig. 7. Fossil human skull (Engis II) found in Grotte d'Engis, Belgium, in 1830. *After T. H. Huxley.* × ½ nat. size. Laboratoire de Paléontologie animale de l'Université de Liège.

Re-evaluation of the Engis remains[9] more than a century after their discovery has confirmed the essential correctness of Schmerling's interpretation : they are indeed the first fossil men to be found and recognized as such (see p. 147).

Lyell, like many others, had doubted whether the human bones and the remains of extinct animals in the caves of Gailenreuth and Bize were coeval, but after he had been to see the evidence in Liège he became convinced (as he recorded some years later) that Schmerling " had accumulated ample evidence to prove that Man had been introduced into the earth at an earlier period than geologists were then willing to believe."[10] In the third edition of his *Principles of Geology* (1834 : 161), Lyell cited Schmerling's findings, but without giving them the weight that he eventually felt they were entitled to.

Although what we might call the battle for the admission of fossil man had really been won by McEnery, Tournal and Schmerling in the years 1829–33, the world at large remained in ignorance until well after 1859 that a great barrier to man's enquiring mind had been removed.

To Boucher de Perthes, Controller of Customs at Abbeville in the second quarter of the last century, goes the credit for having brought to a head the controversy over the question of the antiquity of man. For many years he had made a hobby of collecting antiquities, and in 1836 or 1837 he began to obtain flint axes from the ancient gravels of the Somme. Late in 1838 he read an account of these *haches diluviennes* (Text-figs. 8–10) to the members of the Société d'Emulation d'Abbeville,




FIGS. 8–12. Selection of flints from the Somme gravels figured by Boucher de Perthes, 1847. $\times \frac{1}{4}$ nat. size. Figs. 8–10, *haches diluviennes* (compare Fig. 4). Figs. 11, 12, *industrie antediluvienne*.

but he was not taken seriously, and news of his alleged discoveries did not reach the outside world. Fortunately Boucher de Perthes was not easily daunted ; he quietly continued his researches and in 1846 published the first volume of a work entitled *Antiquités celtiques et antédiluviennes*, proclaiming that the gravels in the suburbs of Abbeville contained stones worked by antediluvian man, and occurring at various depths along with the bones of mammals now extinct. " In spite of their imperfection", he wrote, "these rude stones prove the existence of man as surely as a whole Louvre would have done". The majority of geologists were frankly scornful of his claims. Darwin once admitted that when he read the work of Boucher de Perthes he thought it was rubbish.[11]

The controversy which in various places had been simmering for twenty years or more reached boiling point in the eighteen fifties. The scientific world became split into two camps over acceptance of de Perthes' claims. His opponents had the weight of French academic opinion behind them, but their numbers declined after 1854, when Dr. Rigollot, a distinguished physician who had been on their side, was converted to de Perthes' point of view through finding similar flint axes in fossil-bearing gravel at St. Acheul, a suburb of Amiens.

The battle was eventually resolved through British intervention. In the autumn of 1858, the English palaeontologist Hugh Falconer, passing through France on his way to Sicily, paid a visit to Abbeville, and seeing the disputed evidence for himself was very favourably impressed. In the following April, at Falconer's suggestion, the English geologist Joseph Prestwich visited Abbeville and St. Acheul. After examining the collections and inspecting the gravel pits in company with the archaeologist John Evans, he returned to London, and on May 26th read a paper[12] to the Royal Society announcing his acceptance of the claims made by Boucher de Perthes and Rigollot. This announcement, coming from a geologist of such high repute, had a decisive effect on scientific opinion throughout the world. It was all the more effective because at the same time Prestwich was able to announce that excavations then being carried out at Brixham in Devon by William Pengelly, on behalf of the British Association for the Advancement of Science, had completely confirmed the observations of McEnery at Kent's Cavern : flint tools were turning up in association with bones of extinct animals beneath a layer of stalagmite containing remains of mammoth.

Lyell was present at this historic meeting in London, and later that year in the course of an address to the Geological Section of the British Association, meeting in Aberdeen, he said that he was "fully prepared to corroborate the conclusions . . . laid before the Royal Society by Prestwich".

The year 1859 thus stands out as one of the turning points in the history of human thought : the high antiquity of man was established almost simultaneously with the publication of Darwin's book on the *Origin of Species*. Man's antiquity continued to be doubted by scientific diehards for a decade or two. For example the Permanent Secretary of the Academy of Sciences in Paris—a geologist incidentally—remarked in 1863 : "I do not believe the Human Race was contemporary with *Elephas primigenius* [mammoth]. Cuvier's theory is born of genius, it is still undemolished" ; while even as late as 1875 Victor Meunier's book *Les Ancêtres d'Adam* was suppressed because the publisher feared the displeasure of the Academy.[13] The same book (edited by A. Thieullen) was published in 1900. As Max Planck once remarked : "A new scientific truth does not triumph by convincing its opponents, but rather because its opponents die, and a new generation grows up that is familiar with it".

SECTION I (Notes)

[1] Michèle Mercati died in 1593 ; his book *Metallotheca*, in which ceraunia are figured (p. 243), was published posthumously in Rome, 1717.

[2] FRERE, J. 1800. Account of Flint Weapons discovered at Hoxne in Suffolk (Letter read 22nd June, 1797). *Archaeologia*, London, **13** : 204–205.

[3] DANIEL, G. E. 1950. *A Hundred Years of Archaeology* : 25. London.

[4] SCHEUCHZER, J. J. 1731. *Physica Sacra*, **1**. Augsberg.

[5] See p. 96 and Daniel, G. E. 1950 : 65.

[6] Published *in* PENGELLY, W. 1869. The literature of Kent's Cavern, Part II. *Trans. Devon. Ass.*, Plymouth, **3** : 191–482.

[7] CHEYNIER, A. 1936. *Jouannet, grand-père de la Préhistoire*. Brive.

[8] SCHMERLING, P. C. 1833–34. *Recherches sur Ossements fossiles découverts dans les Cavernes de la Province de Liége* : 59. Liége.

[9] TWIESSELMANN, F. 1952. *In* VALLOIS, H. V. & MOVIUS, H. L. Catalogue des Hommes Fossiles. *C. R. XIXe Sess. Congr. Géol. Int.*, Algers : 37 (95). Note that in Hue, E. 1937. Cranes paléolithiques. *C. R. XIIe Sess. Congr. Préhist. Fr.*, Paris (1936) : 202–204, the accepted usage of Engis I and Engis II has been reversed.

[10] LYELL, C. 1863. *The Geological Evidence of the Antiquity of Man* : 70–71. 4th ed. 1873. London.

[11] DARWIN, F. 1888. *Life and Letters of Charles Darwin*, **3** : 15. London.

[12] PRESTWICH, J. 1859. On the occurrence of Flint-implements, associated with the remains of Animals of Extinct species in beds of a late Geological Period, in France at Amiens and Abbeville, and in England at Hoxne. *Proc. Roy. Soc.*, London, **10** : 50–59. A week later, Evans presented the evidence to the Society of Antiquaries.

[13] BOULE, M. 1923. *Fossil Men* : 16. Edinburgh.

## II. PERIODS AND ERAS

Since the " Diluvium " was supposed to have been formed in an astonishingly short space of time, " diluvial species " and " antediluvian species " were in theory the same, but in the writings of the diluvialists and uniformitarians alike one detects a growing awareness of a sequence of periods. Thus Boucher de Perthes described the flint axes found in the ancient gravels of the Somme as *diluviennes*, but after discovering some apparently worked flints at greater depths in these gravels he began to distinguish these older and more primitively shaped ones as *antediluviennes*[1] (Text-figs. 11, 12). Then again, John Evans noted in his diary during 1859 : " In this bone cave in Devonshire, now being excavated . . . they say they have found arrowheads among the bones . . . I can hardly believe it. It will make my ancient Britons quite modern if Man is carried back in England to the days when Elephants, Rhinoceroses, Hippopotamuses and Tigers were also inhabitants of the country ".[2]

Prehistory was beginning to stretch out. It is difficult for us to realise today that more than a century ago—say when the present writer's grandfather was at school—there were very few people who had any idea that man had a long unrecorded past. The time prior to history, if it was considered at all, was thought of as a kind of fog without discernible landmarks. In Europe, for example, everything with regard to man that was pre-Roman was lumped together as if belonging to a single period. Indeed, when an eighteenth century antiquary described the famous pointed flint implement[3] found in a trench opposite Black Mary's near Grays Inn Lane, his contemporaries could only imagine that it was the head of a spear used by an ancient Briton in attacking one of the elephants which accompanied the Roman army of Claudius. The process of telescoping the human past, which commonly occurred in the minds of scholars prior to the revolution in thought of 1859, is not unknown of course in untutored minds today, judging by countrymen's comments such as " That was in the time of the Romans, 'fore the railways come. . . . "

The conception that man had an extensive prehistoric past seems to have developed more slowly than the notion of a pre-human, geological past, no doubt because there was a greater emotional resistance to new concepts concerning man himself. One of the most important contributions to dispersing the " prehistoric fog " was made in Denmark where Christian Thomson, having to rearrange the large collection of pre-Roman antiquities in the National Museum, found it necessary in 1819 to postulate three chronologically successive ages : Stone Age, Bronze Age and Iron Age. Finds in excavations soon confirmed the reality of this sequence.

Already during the eighteenth century the idea developed that there had been a long pre-human, geological past, divisible into periods on the basis of the succession of strata observed, for example, in course of mining, digging wells and constructing canals. The broad sequence of stratified rocks had been clearly recognized by the Italian geologist Giovanni Arduino (1713–1795), who proposed that they be divided into three age groups, Primary, Secondary and Tertiary. Practical observations in Britain at about the same time led a civil engineer William Smith (" Father of English Geology ") to tabulate the strata in Britain (1799). In 1816 Smith published his great work on *Strata Identified by Organized Fossils*, the foundation of the science of stratigraphy which, as we shall see, has an important part to play in establishing the chronology of early man and his forerunners. These general geological notions did not give rise to such heated controversy as those concerned with the antiquity of man ; they could easily be accommodated to the current beliefs of the diluvialists by presuming that there had been many creations and many deluges. One of Cuvier's students worked out that on the basis of the sequence of fossils there must have been no less than 27 creations.

The strata of the Tertiary group, which included some land and freshwater deposits containing remains of mammals, were subdivided by geologists into a lower group, including the London Clay and the formations in the vicinity of Paris ; a middle group including the sandy formations of Touraine and Bordeaux ; and an upper group comprising all the deposits which were newer than these, including the Diluvium. In course of preparing his *Principles of Geology* (1828–33) Lyell compared the fossil molluscan species in the Tertiary marine formations with those now living, and he found that in the Lower Tertiary not more than 3½ per cent. were identical with those of the present day ;[4] in the Middle Tertiary, 17 per cent. and in the Upper Tertiary, 35–50 per cent. or even more in the most recent beds. In 1833 he proposed names for these sets of strata and the periods which they represented, as follows : *Eocene* for the Lower Tertiary, meaning *dawn* of recent fauna (from the Greek words ηως dawn, καινος recent) ; *Miocene*, for the Middle Tertiary, meaning with fauna containing less recent species than in the succeeding period (from the Greek words for less μειων and recent καινος) ; and *Pliocene* for the Upper Tertiary, from the Greek words for more πλειων and recent. Later,[5] the uppermost part of the Eocene was separated as *Oligocene*, derived from the Greek words for few ολιγος and recent, and the Newer Pliocene was renamed *Pleistocene*, (from the Greek words for most, πλειστος and recent).

There was some uncertainty at first as to how much should be included under the term Pleistocene, and this question has been reopened recently ;[6] but in the third quarter of the nineteenth century the term came into general use to cover the Post-Pliocene deposits commonly called Drift, and formerly known as Diluvium, as distinct from Alluvium.[7] Thus the Pleistocene included glacial deposits, such as till, or boulder clay, and associated outwash or melt-water sands and gravels, river gravels, lake-beds and cave deposits containing remains of mammals now extinct or living in other regions, such as mammoth, woolly rhinoceros, reindeer and hippopotamus. Pleistocene formations of marine origin were also recognized, their occurrence as raised beaches indicating that relative levels of land and sea have changed repeatedly since the Pliocene period. The fossil molluscan shells in these deposits appeared to be indistinguishable from living species, whereas many of the fossil mammals in contemporaneous deposits laid down on the land were species now extinct. Lyell's classification of geological periods was invented on the basis of shell data, and presumably it was for this reason that he found it unnecessary in the first place to distinguish between Post-Pliocene and Recent ; but his final opinion was expressed in these words :—[8]

" In the *Recent* we may comprehend those deposits in which not only all the shells but all the fossil mammals are of living species ; in the *Pleistocene* those strata in which the shells being recent, a portion, and often a considerable one, of the accompanying fossil quadrupeds belongs to extinct species ". He was aware of the arbitrary nature of such classifications, since he added : " Cases will occur where it may be scarcely possible to draw the line of demarcation between the . . . Pleistocene . . . and the recent deposits : and we must expect these difficulties to increase rather than diminish with every advance in our knowledge. . . ."

It being generally agreed after 1859 or thereabouts that man had existed and was widespread well before the end of the Pleistocene period, which included the Ice Age, the question mainly debated by geologists during the second half of the century concerned the dating of the earliest artifacts and human remains in relation to the glacial deposits. It was widely held for a number of years that relics of man contemporary with Pleistocene mammals, whether in river or lake beds or in cave deposits, were always *post*-glacial. Reading the accounts of these old disputes one cannot help wondering if perhaps the old controversy as to whether man was pre- or post-diluvial was really continuing at the back of the debaters' minds, but with new names for the old ideas.

The realization that there had been an Ice Age during comparatively recent geological times was due primarily to the observations of Swiss amateur naturalists, notably Venetz-Sitten, an engineer who propounded the view in 1829 that glaciers had formerly extended on to the plains north of the Alps. Another Swiss amateur geologist, Jean de Chapentier, took the young zoologist Louis Agassiz to the Rhône valley in 1836 and demonstrated to him the evidence of earlier glaciation, mainly in the form of ancient moraines. At first Agassiz doubted the sweeping inferences drawn by these amateur geologists, but his own observations and wide reading convinced him that they were right. He went further than they did, and in 1837 he addressed the Société helvétique on the subject of " a great ice period ".[9] He had been impressed by the wide distribution of erratic, or far-travelled, boulders associated with the superficial deposits known as drift in the northern and temperate parts of Europe, Asia and America. During his travels he later noticed rock surfaces that were scratched and polished in a way which Alpine observations had taught him could only be due to the movement of ice masses. After seeing evidence of this kind in the north of England, Scotland and Ireland during the autumn of 1840 Agassiz concluded that " not only glaciers once existed in the British Isles, but large sheets of ice "[10] resembling those now existing in Greenland ; and he recognized that these ice sheets had been largely responsible for the formation of the unstratified accumulations of boulder clay or till which were attributed by Buckland and others to the Deluge. It is greatly to Buckland's credit that after Agassiz had shown him glacial agencies at work in the Alps, he recanted his former opinion in these words :[11] " Thus the flood that caused the Diluvium which in my ' Bridgewater Treatise ' I have put back to the latest of the many Geological Deluges, was probably due to the melting of the Ice ".

Although Agassiz communicated a paper to the Geological Society of London in 1840 demonstrating the evidence for the former existence of glaciers in Britain, it was not until Archibald Geikie of the Geological Survey published in 1863 an essay on the Glacial Drift of Scotland[12] that boulder clay became generally accepted as the product of land ice.

When Sir John Lubbock issued his book on *Prehistoric Times* (1865), he proposed that the Stone Age should be divided into : (1) that of the Drift, " when Man shared the possession of Europe with the Mammoth, the Cave Bear and the Woolly-haired Rhinoceros . . . " which he termed the *Palaeolithic* period (from παλαιος ancient, and λιθος stone) i.e. Old Stone Age ; and (2) the Later Stone Age, when the fauna consisted of existing species, and when men used polished stone axes, which he termed the *Neolithic* period (from νεος new, and λιθος stone).

The river gravels and other freshwater deposits containing palaeolithic flint implements in southern Britain are mainly later than the most widespread boulder clay and the associated melt-water gravels with northern erratics. The famous lake beds with flint hand-axes at Hoxne in Suffolk were observed by Prestwich to *overlie* a thick boulder clay. The gravels containing similar palaeoliths in the Thames Valley were evidently deposited *after* the river had eroded its way through the northern drift. Consequently the opinion that in Britain man was a " post-glacial " immigrant continued to receive support from many geologists during the third quarter of the last century. This view was indeed difficult to refute so long as only a single till or boulder clay had been observed in any one section. Until the eighteen seventies it was commonly believed that the Glacial epoch was a continuous age of ice, but this was questioned by a few observers, notably the Swiss geologist Morlot (1854), in a paper proposing the division of post-Pliocene time into First Glacial, Diluvian, Second Glacial and Modern epochs.[13] In the early eighteen seventies a number of observers in various parts of Europe found unmistakable evidence that there had been more than one glaciation. James Geikie, younger brother of Archibald Geikie, collected together all the evidence to show that there had been many changes in climate during the glacial epoch, which he concluded was divisible into a series of alternate cold (*glacial*) and warmer or *interglacial* periods. He assembled the data in favour of this conception in his book *The Great Ice Age and its Relation to the Antiquity of Man* (1874).

An important part of the evidence of climatic change during the Pleistocene is derived from studies of the plant and animal remains in deposits of this period. It was noticed early on that the fossil mammalia in cave deposits and freshwater deposits of Drift age included species of temperate habitat such as bison and grisly bear ; species of northern or arctic habitat such as reindeer and musk-ox (also mammoth and woolly rhinoceros); and species of sub-tropical or at least southern habitat such as hippopotamus. The environmental requirements of reindeer and hippopotamus are so extremely different that they cannot have lived contemporaneously in Britain. The requisite habitats are necessarily so far removed from one another that even when Britain was joined to the Continent it was inconceivable, as Geikie pointed out, that hippopotamus and reindeer herds changed places through migrating to and fro with the seasons.

Boyd Dawkins, who considered that seasonal migration might explain the co-mingling of remains of northern and southern species in the same deposit, argued that as the bones of all the species showed the same degree of mineralisation it was not possible to infer that some were derived from older layers. To this Geikie replied :[14] " Mr. Dawkins, I am sure, does not believe that he can distinguish any difference in the state of preservation of a bone say 50,000 years old and that of another say 55,000 years ", and yet the time during which arctic forms lived in Britain may not have been separated by any greater interval from the time when a temperate fauna was introduced. That is to say, he believed that two faunas might be represented in the same deposit of river gravel without being precisely contemporary. Up to the time that Geikie was writing, and indeed for some time after, collectors of fossils from gravel pits and even from cave excavations paid little attention to the details of stratification. With the development of more careful methods of collecting and excavation it eventually became evident that many apparent occurences of northern and southern species in the same layer were simply due to specimens from different but adjacent layers being grouped together by the collectors.

Through observation of cliffs and cuttings in Scotland, Geikie found evidence at several localities of two tills separated by a plane of erosion, and in some places by stratified gravels, sands and peaty muds, indicating a mild interval between two advances of ice. In the Cowdon Burn railway cutting in Renfrewshire, the intercalated beds visible in 1868 yielded fossil remains of a temperate fauna, including giant deer, horse and aurochs (*Bos primigenius*), accompanied by seeds of birch and hazel,[15] whereas a till exposed in the Carham sandpit on the Tweed contained tusks of mammoth and antlers of reindeer.[16] At about the same time that these significant observations were being made in Scotland, Searles V. Wood, Jr. and the Rev. J. L. Rome were busy examining the boulder clays and intercalated deposits exposed along the coast of Yorkshire, and correlating them with comparable layers in south-east England ;[17] other geologists were studying the sequence in Lancashire and Cheshire, where Upper and Lower Boulder Clays, with intervening " Middle Sands " were in evidence. Although no one section showed a complete sequence, Geikie was convinced by the evidence of the fossil content of the various layers, and by their relationship to the stages of erosion of the landscape, that there had been three main interglacial periods. By 1877, when the second edition of his book on the *Great Ice Age* was published, he was in a position to synthesize the scattered evidence, and he produced the following conspectus of the climatic oscillations recorded in the Pleistocene deposits in Britain :[18]

Last Glacial period : Hessle Boulder Clay ; Upper Boulder Clay of Lancashire. (Followed by valley-moraines in mountain districts.)
*Third Interglacial mild period :* Hessle Gravel with *Cyrena* [= *Corbicula*] *fluminalis ;* Middle Sands of Lancashire.
Third Glacial period : Purple Clay of Yorkshire ; Lower Boulder Clay of Lancashire.
*Second Interglacial mild period :* Some intercalated beds ; period of great subaerial erosion.
Second Glacial period : Great Chalky Boulder Clay.
*First Interglacial mild period :* Sand and rolled gravel above Cromer Clay, with temperate marine molluscan shells.
First Glacial period : Cromer Clay (Till) and Contorted Drift.
*Preglacial mild period :* Cromer Forest-bed.

Remarkably little advance on this classification has been made in the last seventy years.

Returning to the question of the geological age of the palaeolithic artifacts found at Hoxne, Geikie pointed out that the boulder clay which underlay them was evidently the Great Chalky Boulder Clay. Thus, far from these implements indicating that man was a post-glacial immigrant, they could equally well be of third or even second interglacial age. In a postscript to the second edition of *The Great Ice Age*[19] Geikie reported that the Fenland geologist, S. B. J. Skertchley, had written to inform him that palaeolithic implements had been found with fossil bones and shells *below* chalky boulder clay near Brandon. In the light of later research one may doubt whether this was the same boulder clay which underlay the Hoxne palaeoliths, but at least there was no longer any doubt that man existed in Britain during an interglacial period.

Geikie paid attention to one line of evidence regarding the antiquity of man which is worth mentioning here as it serves to introduce a method of relative dating much used in more recent years. He pointed out that the valleys of rivers in Southern England had been excavated 50 or 100 feet since the deposition of gravels containing palaeoliths. The ancient gravels of major rivers, such as the Thames or the Somme, lie on shelves or *terraces* flanking the valleys and marking successive stages in the erosion which gave them their present depth. The occurrence of flint implements of the Hoxne type in the 50 ft. and 100 ft. terraces of the Thames was seen by Geikie as an indication of the immense amount of time that must have elapsed since these tools were manufactured.

In summarizing the evidence for the age of the palaeolithic deposits in Britain Geikie wrote :[20] " In short, the palaeolithic deposits dovetail into the glacial drifts. . . . To the last interglacial period . . . we must refer the great bulk of the palaeolithic gravels in the south-east of England. . . . No doubt, however, portions of the ancient tool-bearing gravels, especially in the valley of the Thames . . . may go back to the earlier warm periods of the glacial epoch . . . ; while some may go back to even preglacial ages ".

It is interesting to find that in his classification of the Pleistocene[21] he was ahead of his time and anticipated modern tendencies, for he included preglacial deposits at the base, and counted the present-day as within the same geological period.

| | | |
|---|---|---|
| Post-Tertiary | Pleistocene or Quaternary | Recent<br>Postglacial<br>Late Glacial<br>Middle Glacial<br>Early Glacial<br>Preglacial |
| Tertiary | Pliocene | Crag[22] |

The preponderance of existing species and the presence of man, apparently, throughout Post-Pliocene times led to the idea that the Pleistocene and Recent epochs were best grouped together as a fourth geological era named Quaternary.[23] The equation of Pleistocene with Glacial epoch had left the Recent as equivalent to Post-Glacial ; but to bring it into line with the other period names, Paul Gervais[24] proposed in 1850 that it should be called *Holocene* from the Greek words ὁλος whole, and καινος recent). However it was not until the close of the century that the following classification became generally adopted :

| | |
|---|---|
| Quaternary | Holocene<br>Pleistocene |
| Tertiary | Pliocene<br>Miocene<br>Oligocene<br>Eocene |

By the eighteen sixties there seemed little doubt that man existed early in Quaternary times ; but several questions loomed up as soon as this conclusion was considered in the light of the concept of evolution. Was man's physical form the same in Early and Late Pleistocene times? A small percentage of Recent species of mammalia were in existence at the beginning of the period.[25] Perhaps man was among them—already of the modern species, *Homo sapiens*, at the dawn of the Quaternary era. That was the interpretation that some authorities put on the well-made flint implements reported from relatively early Pleistocene deposits. Were there any fossil remains that confirmed or contradicted this notion? As we shall see, a number of finds of human remains in early Quaternary deposits were reported in the second half of the last century, but there was usually some unresolved doubt, either as to their antiquity or their normality. Was there any evidence in the form of artifacts indicating that man, defined by Benjamin Franklin[26] as the " tool-making animal ", existed in Tertiary times?

Beginning with the discovery of some " cut " bones and chipped flints in the so-called Pliocene sands at St. Prest near Chartres,[27] a considerable controversy developed over this last question. Some claimed that the specimens found at St. Prest proved the existence of Tertiary Man. Others said that the " cuts " on the bones might be the result of animal gnawings, and that the flints could have been chipped by other natural agencies. Similar flints were reported at about the same time from Tertiary deposits in other parts of France, in Portugal and even in California. Quantities of chipped flints were found by Abbé Louis Bourgeois[28] in Lower Miocene deposits at Thenay south of Orleans, and a number of them were examined by a committee of fifteen at the Congress of Anthropology and Prehistoric Archaeology at Brussels in 1872 : nine reported in favour of some of these flints being the work of man, five denied that any flint was artificially chipped, and one could not make up his mind.[29] Some of the flints were reddened and " crackled ", apparently by fire—although the action of thermal springs could not be ruled out, and in any case fires can be of natural origin.

During the eighteen seventies numerous chipped flints were discovered by J. B. Rames[30] in deposits then called Upper Miocene, now regarded as Lower Pliocene, at Puy Courny near Aurillac in the Auvergne, and by Carlos Ribeiro[31] at Otta near Lisbon. De Mortillet and other archaeologists accepted many of these flints as authentic evidence that a rational being had existed before Quaternary times. Enthusiasm on this subject reached its peak in 1879 when de Mortillet[32] argued that as palaeoliths had been made by men differing somewhat from men of the present day, the Tertiary flints must have been flaked by a precursor considerably different from *Homo sapiens*. Carried away by vivid imagination he invented the name *Homosimius* for our Tertiary ape-like precursors ; and he went on to attribute the Thenay flints to *Homosimius bourgeoisi*, the Puy Courny flints to *H. ramesi* and the Otta flints to *H. ribeiroi !*

The same author[33] coined the name *eoliths* for the stones in question, that is to say flints whose natural shape was judged to have been slightly altered to make it more useful as a tool. The later part of the Tertiary era was regarded as the *Eolithic Age* (from the Greek words ηως, dawn, λιθος stone), when naturally shaped stones, it was supposed, were used as implements and occasionally improved. This was the dawn of tool-making which theoretically preceded the Palaeolithic or Old Stone Age coincident with the Pleistocene period.

The enthusiasm for eoliths was infectious. In the eighteen-eighties, Benjamin

Harrison,[34] village grocer at Ightham in Kent, whose interest in geology had been aroused in boyhood by reading Lyell's *Elements*, began searching the gravels near the crest of the North Downs, which form the remnant of an ancient plateau. In this gravel he found numerous flints with margins chipped and notched like scrapers and borers. The deposit was regarded by geologists at that time as of Pliocene age. Prestwich showed great interest in Harrison's finds, which were demonstrated at a conversazione of the Royal Society in 1895, and for many years they were widely accepted as the implements of Tertiary Man.

Fortunately for science there are always some sceptics who challenge the current orthodoxy, and the tide of opinion gradually turned against eoliths in the course of the present century, beginning with the discovery, reported by Marcellin Boule[35] that lumps of flint, that is to say flint nodules, whirled around in the cement-mixing mills at Nantes, were frequently broken and chipped into eolith-like forms. Whirlpools on river-beds were evidently possible causes of the formation of eoliths ; and there were many other agencies too which may have produced them, notably subsoil pressures. The Abbé Breuil[36] found a bed of flints at the base of the Eocene deposits at Cleremont (Oise) which had quite evidently been broken and chipped into eolithic forms by the pressures due to movements of the deposits as they settled in adjustment to collapses of the underlying Chalk, which is continually being dissolved by percolating water. In England, Hazzledine Warren made a similar discovery at Grays in Essex, where flint nodules forming the " Bull-head bed " at the junction of the Chalk and the Eocene sands have been fractured and flaked into eolithic forms by these foundering movements.[37] Other natural agencies which are known to produce pseudo-artifacts, or naturifacts, include storm waves, cliff-falls, fire, glaciers, frost and soil-creep, particularly of the kind known as solifluxion due to alternate freezing and thawing under periglacial conditions.

It was only to be expected that man's earliest efforts at making tools should be barely distinguishable from the works of Nature. Indeed, one French prehistorian remarked : " Man made one, God made ten thousand. God help the man who can distinguish the one in the ten thousand ". So long as there is *any* doubt about the artificial character of a chipped stone it cannot be regarded as an indication of the presence of man.

Flaked flints have been discovered in large quantities mainly during the present century in and below the Crags of East Anglia. Whether any of these is humanly worked is now regarded as extremely doubtful. Reid Moir, their chief protagonist, always claimed that they were not eoliths, but " Pre-Palaeolithic artifacts ",[38] a distinction one would think presupposing some doubt about the former. However, the late Professor Alfred Barnes, who was for many years one of the strongest believers in the humanity of Sub-Crag flakings, showed eventually by application of statistical analysis that they are of the high-angled type characteristic of the work of nature.[39] In any case, the Red Crag, Norwich Crag and Weybourne Crag, like the sands of St. Prest, are now regarded as Lower Pleistocene.

Following the archaeological evidence for man's antiquity to its rather dubious limits, it must be admitted that there is really no proof in Europe that humanity had emerged before the beginning of Quaternary times ; indeed the same is true in Asia and Africa.

We may now more usefully turn to the evidence provided by actual remains of man, considered approximately in their order of discovery and in the light of developing theories and techniques.

SECTION II (Notes)

1 Boucher de Perthes. 1847. *Antiquités Celtiques et Antédiluviennes.* Paris. Plates 17–23, *Haches diluviennes* ; pls. 27–32, *couteaux diluviennes* ; pls. 50–80, *industries primitives de la period ante-diluviennes.* Many of the flints in these latter plates were in fact " figure-stones " now regarded as natural.

2 Evans, J. 1943. *Time and Chance* : 100. London.

3 Hand-axe found in 1690, now in the British Museum. Essentially similar to Text-fig. 4.

4 More detailed studies eventually showed that even in the uppermost division of the Eocene as originally defined, later separated as Oligocene by most authors, not more than one per cent. of the marine mollusca are of Recent species (Davies, A. M. 1934. *Tertiary Faunas,* **2** : 57. London).

5 Oligocene was proposed by Beyrich, a German specialist on mollusca, in 1839.

6 Lyell (1833 *Principles of Geology,* **3** : 52. London) used the term " Recent epoch " for the " time which has elapsed since the earth has been tenanted by Man ". As thus defined, " Recent " meant Post-Pliocene, and included both the Pleistocene and the Recent as now understood. Later he proposed (Lyell, C. 1839. *Élements de Géologie* : 621. Paris) the term Pleistocene " as an abbreviation for Newer Pliocene ", defined as comprising deposits containing more than 70 per cent. Recent species of mollusca (compared with 40–70 per cent. in the " Older Pliocene "). At the time when he introduced this new term Lyell did not state precisely where its upper and lower boundaries were to be drawn, although by provisionally reclassifying the Norwich Crag as older or true Pliocene he intended the base of the Pleistocene to be above that deposit. It also included some boulder drift (i.e. glacial deposits), but apparently not the valley gravels with flint implements, which were still regarded as Recent. In subsequent works Lyell showed a disinclination to continue using the term Pleistocene, but it had become popular as a result of being adopted in a brilliant essay by the young English geologist Edward Forbes (1846) on the Geological Relations of the existing Fauna and Flora of the British Isles, which stressed the geological and biological significance of the Glacial Epoch. In 1865 (*Elements of Geology,* 6th ed.) Lyell wrote : " I think it best entirely to abstain from the use of the term Pleistocene in this work. . .". He added in a footnote : " If geologists still think it convenient to retain the term Pleistocene, I would recommend them to use it not in the sense originally proposed by me [to mean older Post-Tertiary formations], nor in the somewhat vague manner in which it was applied by Edward Forbes, but in place of Post-Pliocene as this term is defined in the present work ". In an accompanying table of strata, the Red Crag, with only 60 per cent. of the mollusca belonging to Recent species, is classified as Older Pliocene, the Norwich Crag, with 89 per cent., is counted as Newer Pliocene, while the Glacial Drift, the Liège and Devon cave deposits, and the Somme gravels, with flint implements and extinct mammalia, are classed as Post-Pliocene. Deposits in which shells and mammalia are all of living species, for example the Danish peats with polished stone and bronze implements, are classed as Recent.

During the twentieth century the usage of the term Pleistocene has again altered : its base in Britain is now drawn below the Red Crag, while at the upper end some authors would eliminate any formal separation of " Recent " deposits, preferring to regard the age in which we live as a continuation of the Pleistocene (Flint, R. F. 1957. *Glacial and Pleistocene Geology* : 382–384, London).

7 The term Diluvium was introduced by Gideon Mantell (1822 *Fossils of the South Downs* : 274. London) to mean superficial deposits laid down by agencies no longer operating, particularly

the Biblical Deluge, as distinct from Alluvium, the term for deposits formed by agencies still in force such as existing rivers. In Germany Diluvium is still used as a term synonymous with Pleistocene deposits, but in Britain after the middle of the last century it was replaced by the term *Drift*. The expression " the Drift " originated mainly in connection with the theory that many of the Post-Pliocene deposits, especially those containing erratic or far-travelled boulders, had formed by drifting icebergs at a time when extensive areas of land in the northern hemisphere were submerged (North, F. J. 1943. *Proc. Geol. Ass. Lond.*, **54** : 20). This Drift Theory served as a sort of mental stepping stone between the Diluvial Theory and the Glacial Theory. One group of geologists, the Fluvialists, tried to explain the disposition of almost all superficial deposits by reference to rivers. All these theories had elements of truth in them, and today it is recognized that Pleistocene deposits include products of all the known sedimentary agencies, winds, rain, rivers, floods, lakes, frost, glaciers, floating ice and seas.

8 Lyell, C. *The Geological Evidence of the Antiquity of Man.* Everyman's Library Ed., edited by R. H. Rastall : 4. 1914. London.

9 Agassiz commonly receives all or most of the credit for originating the concept of the Ice Age, but this does less than justice to other pioneers and particularly to those colleagues from whom he undoubtedly learnt much of his glaciology, such as Charpentier and Karl Schimper (see de Beer, G. R. 1963. *Charles Darwin* : 75–76, London). Nor should it be forgotten that James Hutton in Edinburgh concluded with remarkable percipience in 1795 that boulders of Alpine rock noted by de Saussure on the slopes of the Jura mountains had been transported by ice. As regards the idea of continental glaciation, Agassiz was anticipated by A. Bernhardi (1832) who published a paper (*N. Jb. Min. Geol. Paläont.*, Stuttgart, **3** : 257–267) expressing the view that in former times ice had extended overland into Germany from the north polar region. When all is said and done perhaps Agassiz's main contribution in this field was in spreading the new idea, which sounded the death knell of theories based on the Deluge, or on submergence. Thus it was indirectly through Agassiz's visit to Britain in 1840 that Lyell adopted the idea of land-ice as the agency responsible for the formation of certain deposits of till which formerly he attributed to drifting icebergs. For references and fuller discussion of these matters see North, F. J. 1943. Centenary of the Glacial Theory. *Proc. Geol. Ass. Lond.*, **54** : 1–28.

10 Agassiz, L. 1840. On glaciers, and the evidence of their having once existed in Scotland, Ireland and England. *Proc. Geol. Soc. Lond.*, **3** : 327–332.

11 Sollas, W. J. 1905. *The Age of the Earth and Other Essays* : 247. London.

12 Geikie, A. 1863. The Phenomena of the Glacial Drift of Scotland. *Trans. Geol. Soc. Glasgow*, **1** : 2.

13 Morlot, A. 1854. Notice sur le Quaternaire en Suisse. *Bull. Soc. vaud. Sci. nat.*, Lausanne, **4** : 41–45.

14 Geikie, J. 1877. *The Great Ice Age* : 523. 2nd ed. London.

15 Geikie, J. 1877. *The Great Ice Age* : 127. 2nd ed. London. This author first formulated the concept of an interglacial period in 1871 (*Geol. Mag.*, London, **8** : 545–553). Earlier writers in Britain had used the term interglacial, but only in the sense of *intra*glacial.

16 Geikie, J. 1877. *The Great Ice Age* : 129. 2nd ed. London.

17 Wood, S. V. & Rome, J. L. 1868. On the Glacial and Postglacial Structure of Lincolnshire and South-east Yorkshire. *Quart. J. Geol. Soc. Lond.*, **24** : 146–184.

18 Geikie, J. 1877. *The Great Ice Age* : 393. 2nd ed. London. The only fundamental error in this author's conception of the Pleistocene was his belief that Britain was submerged during the " last Interglacial " period to a depth of up to 1,300 feet. This misconception was based on the occurrence of shelly drift at that height, for instance on Moel Tryfaen in Wales. Subsequently it was shown that such deposition was the result of coastal ice being thrust up under pressure from the main ice-caps, whose heads were at still greater elevations.

19 Geikie, J. 1877 : 565.

20 Geikie, J. 1877 : 531–532.

21 Geikie, J. 1877. *The Great Ice Age* : 566.
22 *Crag* is a Suffolk dialect term for the shelly marine sands of Upper Pliocene and Lower Pleistocene age which occur extensively in East Anglia. The term probably came from the Celtic word *cregga* meaning a shell (Arkell, W. J. & Tomkieff, S. I. 1953. *English Rock Names* : 31. Oxford).
23 The term Quaternary was introduced by Desnoyers in 1829 (*Ann. Sci. nat.*, Paris, **16** : 193), but it was first used by Reboul on a faunal basis to mean Post-Pliocene deposits of prehistoric and historic periods (1833 *Géologie de la période Quaternaire.* Paris).
24 *Holocene* was first proposed in 1850 by Paul Gervais for post-Pleistocene deposits (*Mém. Acad. Montpellier* (Sci.) **1** : 413) ; but it was not generally adopted until the end of the century when the term was independently proposed by B. B. Woodward (1897 *Essex Nat.*, Buckhurst Hill, **10** : 92). The late Mr. A. S. Kennard told the present writer that the term was suggested by an intelligent working man who wrote to Dr. Henry Woodward pointing out that such a term seemed to be needed ; and Dr. Woodward passed the letter on to B. B. Woodward who decided to introduce it in his next paper.
25 For example *Hippopotamus amphibius.*
26 Quoted in Boswell's *Life of Johnson* under 7 April, 1778.
27 Desnoyers, J. P. F. S. 1868. *C. R. Acad. Sci. Paris*, **1868** : 1077, 1082, 1199 ; Bourgeois, L. 1867. *C. R. Acad. Sci. Paris*, **1867** : 47.
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## III. EARLY ATTEMPTS AT DATING : AURIGNAC, NEANDERTHAL AND MOULIN-QUIGNON

We have seen that early in the last century human skeletal remains were found in Pleistocene cave deposits at a number of localities in Europe, and that some were eventually accepted as contemporaneous with the associated extinct fauna, the most notable examples being the Paviland skeleton (1823) and the Engis skulls (1830).

In 1852 a labourer mending a road across a hillside at Aurignac in the Haute Garonne province of southern France noticed a rabbit-hole, and reaching into it as far as he could, perhaps hoping to catch a rabbit, he drew out a human limb-bone.

His curiosity aroused, he dug a trench into the hillside and revealed a cave whose mouth had been closed by a vertical slab of limestone, and behind which there was a cavity almost filled with human bones representing seventeen skeletons of almost all ages. The mayor of Aurignac decreed that all the human bones must be reburied in the local Christian cemetery. The labourer's trench had also brought to light some bones of extinct animals and bone carvings. When Edouard Lartet, a lawyer who had turned to palaeontology and prehistory, heard of these finds eight years later he visited Aurignac and began digging into the deposits on the slope below the cave. He discovered a number of hearths and a fair number of flint implements, bone points and worked pieces of reindeer antler, together with bones of cave-bear, mammoth, woolly rhinoceros and bison (Text-fig. 13).

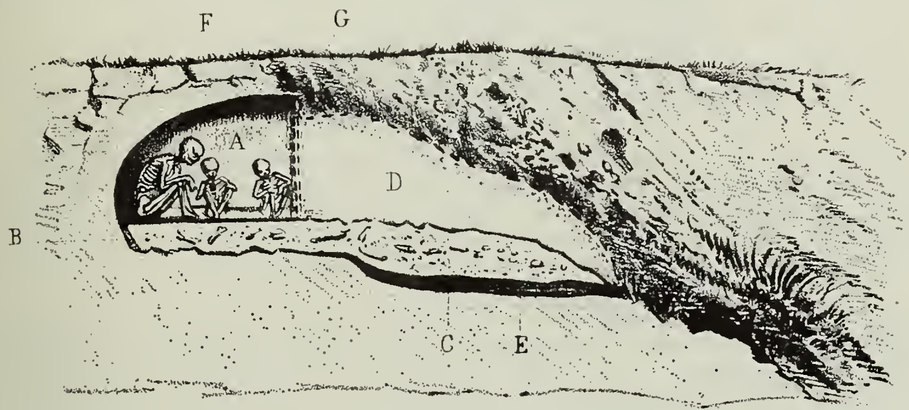



FIG. 13. The cave at Aurignac as figured by Edouard Lartet. A, Burial chamber, presumed Neolithic ; B, Upper Palaeolithic (Aurignacian) occupation deposit.

Lartet formed the opinion that the human skeletons and the glacial fauna at Aurignac were contemporaneous,[1] but this view was disputed by other investigators. The final conclusion was that the human skeletons represented a collective burial of the Neolithic period on top of a disturbed cave deposit of Upper Palaeolithic age.[2] Lartet found some detached human bones mixed with bones of glacial mammals in the substratum of the burial chamber. At his request, chemical analysis was made of one of the human bones, as well as of bones of associated rhinoceros and other extinct animals. All the analysed bones proved to contain the same percentage of nitrogen, that is to say they had all lost about the same proportion of gelatine. This is of historic interest because it was the first application of what has become known more recently as the collagen or *nitrogen test* for the relative dating of bones. The result was not considered conclusive by Lartet's critics because of the possibility that the loss of gelatine in ageing bones only proceeds so far and no further so long as the bone is enveloped in matrix. As Lyell said:[3] " . . . had the human skeletons been found to contain more gelatine than those of the extinct mammalia, it would have shown they were the more modern of the two ". The fact that they contained the same amount was inconclusive.

Up to the middle of the last century none of the human remains which had been found associated with Pleistocene mammals showed features clearly distinguishing them from men living today. The anatomist George Busk considered that the well authenticated adult Engis skull, for example, although narrow in the forehead might be matched among skulls of individuals of the European race, while Thomas Huxley showed by measurement that it fell well within the range of variation of modern Australian skulls.

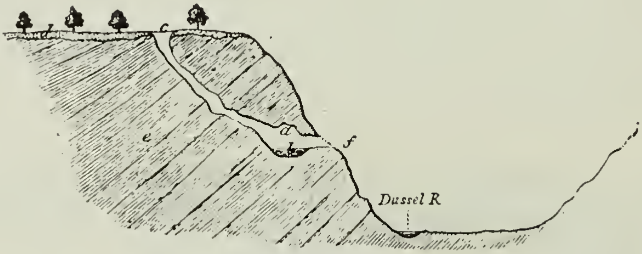



Fig. 14. Section of the Neanderthal Cave near Düsseldorf. *After Lyell.* (*a*) Cavern 60 feet above the Dussel, and 100 feet below the surface of the country at *c* ; (*b*) Loam covering the floor of the cave near the bottom of which the human skeleton was found ; (*b, c*) Rent connecting the cave with the upper surface of the country ; (*d*) Superficial sandy loam ; (*e*) Devonian limestone ; (*f*) Terrace, or ledge of rock.

In August 1856 a remarkable fossil human skull with associated limb-bones came to light in Germany. The bones were in a muddy cave deposit exposed during the quarrying of limestone in the ravine known as Neanderthal near Düsseldorf in the Rhineland[4] (Text-fig. 14). The remains were saved from destruction by Dr. C. Fuhlrott and described in the following year by Professor H. Schaaffhausen of Bonn. After comparing the Neanderthal cranium (Text-fig. 15) with many others, ancient and modern, the latter concluded:[5] " But the human bones and cranium from the Neanderthal exceed all the rest in those peculiarities of conforma-

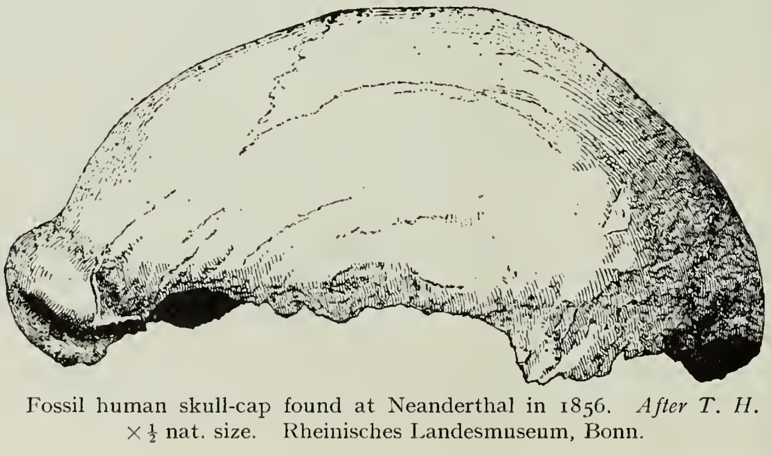


Fig. 15. Fossil human skull-cap found at Neanderthal in 1856. *After T. H. Huxley.* × ½ nat. size. Rheinisches Landesmuseum, Bonn.

tion which lead to the conclusion of their belonging to a barbarous and savage race ". And further, he thought that they might " be regarded as the most ancient memorial of the early inhabitants of Europe ".

Great interest was eventually aroused by this skull, particularly in view of its possible bearing on the animal origins of man, a subject which was soon to be much in the minds of those who realized the full implication of Darwin's *Origin of Species* published in 1859. The German anthropologist Virchow had declared that the skull was that of a pathological idiot. Huxley on the other hand, after making a detailed study of a cast of the skull which had been sent to him, accepted it as human and as undiseased. He wrote:[6] " In truth the Neanderthal cranium has most extraordinary characters ". He commented especially on its vast development of superciliary (eyebrow) ridges, extensive frontal sinuses, retreating forehead, very low vault and flat protruding occipital region. " Under whatever aspect we view this cranium . . . we meet with ape-like characters, stamping it as the most pithecoid of human crania yet discovered ". But having said this he proceeded to stress the contrary indications. The cranial capacity was estimated to have been about 75 cubic inches (*c.* 1230 cc.), a figure almost identical with that quoted as the average cranial capacity of Hottentots. Moreover, after comparing it with a rugged male skull from the Neolithic tumulus at Borreby in Denmark, and with Australian aboriginal skulls, he concluded that the Neanderthal cranium was not an isolated type intermediate between apes and man, but rather " an extreme term in a series leading gradually from it to the highest and best developed of human crania ".

Huxley also pointed out that the dimensions of the other bones of the skeleton showed that both in absolute height and relative proportions the limbs of Neanderthal Man were quite like those of a modern European of medium stature. It was true, he said, the bones were stouter, but " The Patagonians, exposed without shelter or protection to a climate possibly not very dissimilar from that of Europe at the time during which the Neanderthal Men lived, are remarkable for the stoutness of their limb bones ".

A critical question naturally was the antiquity of the Neanderthal skeleton. No fossil mammalian remains were reported in association, although the canine of a bear was found in a lateral branch of the same cave,[7] and fossils of the Mammoth fauna occurred in a similar cave only 133 paces away.[8] Schaaffhausen reported that the bones of the Neanderthal skeleton " adhere strongly to the tongue, although as proved by the use of hydrochloric acid, the greater part of the cartilage is still retained in them, which appears, however, to have undergone that transformation into gelatine which has been observed by v. Bibra in fossil bones ". [This early recognition of denatured collagen in fossil bone is of considerable interest.][9] " The surface of all the bones is in many places covered with minute black specks, which, more especially under a lens, are seen to be formed of very delicate *dendrites*. . . . They consist of a ferruginous compound, and from their black colour may be supposed to contain manganese " (Text-fig. 16).

It had long been supposed that the presence of dendrites on a bone was a mark of distinction between truly fossilized, Pleistocene, bones and those which had been mixed with a Pleistocene deposit at a recent date. However, Professor von Meyer told Schaaffhausen that he had seen dendrites of undoubtedly recent origin (on paper!), and furthermore, that he possessed a dog's skull of Roman age which was in no way distinguishable from fossil bones from Frankish caves, presenting the same colour and adhering to the tongue—" so this character also, which at a former meeting of German naturalists in Bonn, gave rise to amusing scenes between Buckland and Schmerling, is no longer of any value ".[10]

FIG. 16. Dendrite on bone. Enlarged.

So long as no other skulls of the same type were known, and so long as there was no direct evidence of its antiquity, views as to the date of the Neanderthal Man naturally varied widely. Professor F. Mayer of Bonn regarded the skeleton as probably that of a " rickety Mongolian Cossack " who, on his way through Germany towards France in 1814, had crept into the cave and died.[11] Schaaffhausen on the other hand was convinced that the man " belonged to a period antecedent to the time of the Celts and Germans ", perhaps " derived from one of the wild races of Northwestern Europe, spoken of by the Latin writers ", but doubtless " traceable to a period at which the latest animals of the diluvium still existed".

Lyell thought that von Meyer had overdone the discrediting of the usually accepted criteria of fossilization. The profuse dendrites on the outer and inner surfaces of the cranium, together with the fact that the texture of the bone agreed with that of typical Pleistocene fossils, led him to conclude : " On the whole I think it probable that this fossil may be of about the same age as those found by Schmerling in the Liège caverns . . . ".

While Huxley regarded the Neanderthal skull as representing no more than an extreme variant of *Homo sapiens*, William King, anatomist at Queen's College, Galway, considered that the skull was so eminently ape-like that he doubted whether it could be grouped with existing man, and argued that it was better treated at least as a distinct species.[12] At the meeting of the British Association for the Advancement of Science, held in Newcastle in 1863, he proposed the name *Homo neanderthalensis*, and this was published in the following year.

The idea that the world had at one time been peopled by men of a species now extinct was new, and although there has been to some extent a swing back to Huxley's interpretation of Neanderthal Man during recent years, nevertheless King's recognition that this was a type of man who flourished during the Pleistocene period and has since died out was in fact a bold one and contributed considerably to the development of anthropological thought.

In the following year, at the meeting of the British Association in Bath, George Busk,[13] Professor of Anatomy at the Royal College of Surgeons, gave an account of another fossil skull (Plate 1), which had recently been sent to him from Gibraltar by Captain Brome, Governor of the Military Prison there.[14] The skull had been discovered during work in Forbes Quarry on the North Front, and presented to the Gibraltar Scientific Society by Lieutenant Flint of the Royal Artillery on March 3rd 1848, but the news had not been published. Busk recognized that this skull was of the same type as the Neanderthal skull, but it was more complete, with face, upper jaw and teeth preserved. The palaeontologist Hugh Falconer had also examined it, and in a letter which he had written to Busk before the British Association meeting (1864) he proposed the name *Homo calpicus* (after Calpé, the ancient name of Gibraltar) for the extinct species of mankind which it represented.[15] This name was not published at the time but since the skull was identifiable with that of Neanderthal, the name proposed by King which was already published would have had priority.

Although the Gibraltar skull was in fact the second[16] example of *Homo neanderthalensis* to be made known to the scientific world, full confirmation that King had been right in regarding the Neanderthal Man as representative of a distinct Pleistocene branch of mankind did not come until 1886 when two skeletons with skulls of the same remarkable form were discovered in cave deposits at Spy near Namur in Belgium.[17]

From the dating point of view the importance of the discovery at Spy lay in the fact that the human remains were excavated with scientific precision. Thus it was certain that they were found in a layer containing bones of woolly rhinoceros and mammoth, and were associated with Palaeolithic implements of a well-defined type (p. 130), termed Mousterian, known to be later than the hand-axe industries, found for instance in the Somme gravels at Abbeville and St. Acheul, which were later termed Chellean.

The problem which now began to emerge was whether *Homo neanderthalensis* had preceded or existed alongside *Homo sapiens*. Closely linked with this problem was the question of the physical character of the men who had made the Chellean hand-axes. There had been a fair number of discoveries of fossil or apparently fossil remains of *Homo sapiens*, some in deposits with Upper Pleistocene fauna (including mammoth, woolly rhinoceros and reindeer), which might be contemporary or more probably later than the Neanderthal species, for example in the Liège caves ; but others, much more puzzling, were in considerably older deposits.

For many years Boucher de Perthes had cherished the hope of finding bones of the men who made the flint hand-axes (*haches*) which he had been the first to recognize as human artifacts in the terrace gravels of the Somme. It is said[18] that he had offered 200 francs reward to any of the gravel diggers who should find fossil human bones with these early flint tools. As the men only earned two francs a week this was a large reward. He was now seventy-five years old. How much longer would he have to wait ? On March 23rd, 1863, one of the diggers or *terrassiers* brought to him two flint *haches*, and what appeared to be a scrap of fossil bone covered by dark sandy deposit, which the man said had been found near the bottom of the gravel which was then being dug in the Moulin-Quignon pit near Abbeville. On removing its sandy matrix, Boucher de Perthes found that the " fossil bone " was actually a human tooth. Five days later he was called to the same gravel pit, where he was shown a fragment of bone projecting from a black seam of sandy gravel (*couche noire*), about 15 feet below the surface, close to the base of the section. On removing this fragment with his own hands, he found it was the left half of a human jawbone, or mandible, with the second molar still in place. The discovery was announced in a local newspaper on April 9th, and Prestwich, Falconer and Evans who happened to be in France at the time decided to visit the site in the following week. Evans and Prestwich arrived first, and their suspicions were immediately aroused. They were convinced that the *haches* from the black seam of gravel which had yielded the jawbone were modern forgeries. Falconer went later, and his first impression of the jaw was favourable to its being of fossil antiquity, but after returning to London, as soon as he had had an opportunity to scrutinize the material he had taken back with him, doubts arose in his mind. The axes looked spurious, and the isolated molar tooth which he had been allowed to borrow and to saw in half evidently contained a great deal of gelatine. On April 21st, he wrote to Edouard Lartet, who had possession of the jaw, saying that Evans, Prestwich, Busk, and he were opposed to the authenticity of the isolated molar and the *haches*. Meanwhile news of the discovery of the jaw, assumed to be authentic, had been communicated to the Royal Society in London, and the Academy of Sciences in Paris. On April 25th *The Times* published a letter from Falconer strongly questioning the authenticity of the *haches* and the jawbone. This cleavage of opinion resulted in the French *savants* promptly inviting their English challengers to meet them at a conference in Paris, beginning on May 9th. The conference lasted for five days. The report on its proceedings[19] and the notes prepared by Falconer in the course of these deliberations are still of unusual interest (Text-fig. 17).

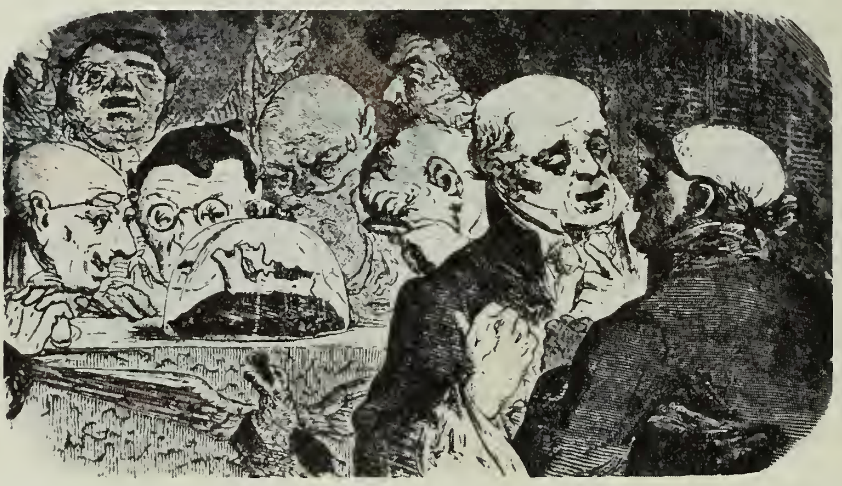


FIG. 17. Discussion on the Moulin-Quignon jaw at the Academy of Sciences, Paris, *After L'Illustration du Midi*, 1863.

Three lines of evidence were considered : the intrinsic evidence of the jawbone ; the intrinsic evidence of the *haches* ; and the extrinsic evidence, that is to say the geology of the site and the circumstances of the discovery.

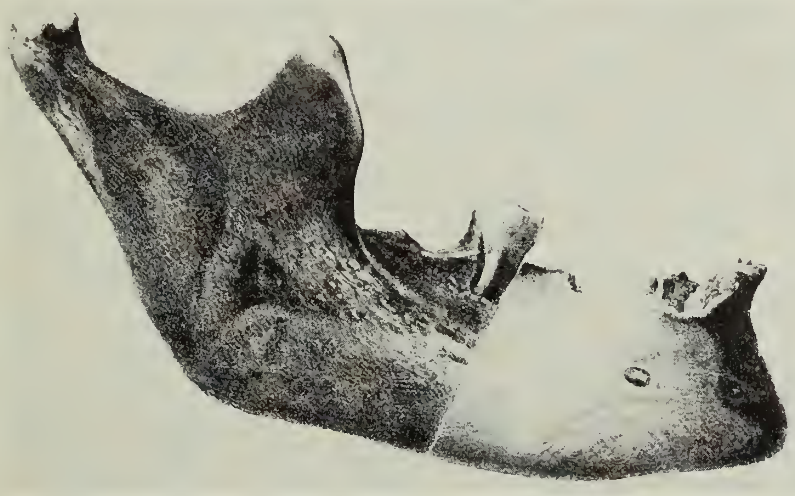


FIG. 18. Moulin-Quignon jaw. *After Delesse.* Nat. size. Musée de l'Homme, Paris.

The form or morphology of the jaw was not discussed, but clearly it conformed with that of *Homo sapiens* (Text-fig. 18). When the question of whether the condition of the jawbone was consistent with fossil antiquity came up for consideration, Busk was allowed to saw it in half, just in front of the solitary molar, so that the section included a portion of the roots. Falconer pointed out the many features which were against the jaw being contemporary with the black mangano-ferruginous gravel in which it was said to have lain. It showed no abrasion or appearance of having been rolled on the river bed, the thin coronoid process was as perfectly preserved as in a Recent jawbone, while the black sandy coating washed off with the greatest ease when the specimen was brushed in warm water. There were no dendrites on the bone, which therefore differed conspicuously from bones of undoubted fossil antiquity in the Somme gravels. The true fossil bones also contrasted strongly with the Moulin-Quignon jaw in having lost most of their gelatine. On sawing, the jawbone proved to be hard and firm, and the " fresh section afforded a distinct odour of sawn bone ". Internally the bone structure was free from any kind of mineral impregnation. The dental nerve canal contained fine grey sand, but without any speck of the black matter which was so conspicuous in the enveloping matrix. The section of the root of the molar " showed that the dentine, so far as it was exposed, was perfectly white, full of gelatine, and in no respect different in appearance from that of a Recent tooth ". [These words were unwittingly echoed when the notorious Piltdown jawbone was being re-described in 1950.] The body of the molar in the jaw showed carious decay, which we now know to have been rare in Palaeolithic people.

The members of the conference heard evidence that in some circumstances fossil bones and teeth retain a considerable proportion of their organic matter, or gelatine. Two teeth of the extinct cave-hyaena from Pleistocene deposits in Auvers were produced by Monsieur Delesse in support of this point. But Busk, while admitting that the jawbone might be of considerable age, said that he was convinced that it was not of high antiquity, for it "presented no character which may not be found in cemetery bones". He compared the jaw with a specimen from a Gallo-Roman cemetery near Amiens, from which it only differed in being slightly less altered, and in having the sand grains in the dental canal. All these comparisons were qualitative rather than quantitative. "One important part of the intrinsic evidence", Falconer wrote,[20] "still remained to be determined, namely the chemical analysis of the bone, but the conference was too pressed for time to wait for it".

The best part of three days were devoted to considering the intrinsic evidence of the *haches* or hand-axes recorded from the *couche noire*. These differed from the undoubtedly genuine hand-axes found in the Somme gravels in a number of important respects. According to Falconer the facets were deeper and narrower, corresponding with iron-struck, rather than with stone-struck flakes, and were disposed with a greater sameness of pattern as though produced by one or two hands. The ridges between the flake facets were higher and sharper. The surfaces had the dullness of recent fracture, rather than the gleam of ancient flint artifacts from gravel, and they lacked dendrites (Text-fig. 16) and all trace of patina or ferruginous staining. Some had a ferruginous incrustation, but this proved to be quite superficial and easily washed off.

The conference proceeded to Abbeville on May 12, and in the Moulin-Quignon pit watched a large party of workmen digging in the gravel in search of implements. Five *haches* "were yielded during the operations of the day; and in no case was any circumstance observed or noted which would justify the opinion that they had been fraudulently introduced".[21] Four of these worked flints were later examined in England, and although one showed the characteristics of a genuine palaeolith, the other three bore all the signs of recent fabrication. However, the French members of the conference were satisfied that Boucher de Perthes was not being deceived. They admitted the difficulty of distinguishing the genuine from the counterfeit in some instances, but they argued that if the position of an axe in a deposit was unquestionable, the axe itself must be accepted as genuine.

As regards the extrinsic evidence, one of the geologists who visited the pit on May 12th made a suggestion which at first seemed to offer a happier solution than either doubtfully accepting the jawbone as Pleistocene, or regarding it as a fraudulent intrusion. He pointed out that there were deep "sand pipes" extending throughout the whole thickness of the ancient gravels in the Moulin-Quignon pit, one close to where the jaw is said to have been found, and the deposits in these pipes might be of Post-Pleistocene age. Possibly the jawbone had in reality come from such a deposit. However, the majority of those who inspected the section considered that the *couche noire* which yielded the jawbone unquestionably belonged to the high-level terrace of the Somme which contained the early hand-axes. Chemical tests on the material of the bed showed that it contained no humic or other organic matter.

The following conclusions were reached on the last day of the conference, and forwarded to the Academy of Sciences for consideration at its session on May 18th, 1863 :—

(1) The jawbone was *not* fraudulently introduced into the Moulin-Quignon pit.

(2) All the members present, with the exception of Falconer and Busk, incline to think that the jaw-bone is contemporaneous with the *couche noire* in which it was found.

(3) The *haches* presented as having been found in the lower part of the section in the Moulin-Quignon pit are for the most part authentic.

The English members of the conference and their colleagues at home were far from satisfied. John Evans wrote a letter to the *Athenaeum* of June 6th protesting that all the *haches* recently found in the Moulin-Quignon pit were in his opinion spurious.[22] He also wrote to Boucher de Perthes with the request that one of his most trusted workers, Mr. H. Keeping, should be allowed to watch the excavations in progress in this pit for one week. Boucher de Perthes agreed. At the end of the week's vigil, Keeping had all the evidence required to prove that *haches* were being fraudulently planted in the gravels.[23] In a letter to the *Athenaeum* of July 4th, 1863, Evans described Keeping's report and said (p. 20) :

" I sincerely hope that the human jaw from Moulin-Quignon may from this time forward be consigned to oblivion. *Requiescat in pace!* " But he added in conclusion that these particular finds being proved fraudulent " has nothing whatever to do with the evidence afforded of the antiquity of Man by his work discovered in the drift . . . the general rule holds good, that the existence of counterfeits presupposes the existence of genuine originals ".

In the following year a second jaw-bone and other human bones were found in the Moulin-Quignon pit, and were accepted by some French authorities as confirmation of the authenticity of the original find ; but by the scientific world at large they were simply taken as an indication that the *terrassiers* had again succeeded in their trickery. The Moulin-Quignon jaw received its *coup de grâce* in 1950 when it was submitted to the fluorine test.

Subsequently to the Paris conference the anatomical form or morphology of the Moulin-Quignon specimen was attentively studied by the French anthropologist Prüner-Bey,[25] who found that it corresponded closely to a mandible of a late prehistoric skull from Switzerland, and he concluded that the Moulin-Quignon specimen could well have belonged to a brachycephalic individual " of the stone age ", by which he meant in this case Neolithic.

The fact that the controversial jaw was patently indistinguishable from jaws of modern *Homo sapiens* had almost been lost sight of in the heat of the discussions on its age and authenticity. However, this aspect of the matter must have been brought sharply to mind when, a year or so later, a fossilized lower jaw obviously differing somewhat from the modern type, and perhaps referable to the Neanderthal species, was found with glacial fauna in the cave called Trou de la Naulette, near Dinant.

It was described by Prüner-Bey.[25] While adding to knowledge, it did not help towards solving the problem of human origins.

In his famous essay on the Engis and Neanderthal skulls, Huxley[26] said that these fossil remains of man did not seem to " take us appreciably nearer to that lower pithecoid form, by the modification of which he [man] has, probably, become what he is ". Indeed he thought that judging by their flint " axes " and " knives " the earliest men of the glacial period were probably not inferior to the lowest savages of our own time. He asked : " Where, then, must we look for primaeval Man ? Was the oldest *Homo sapiens* Pliocene or Miocene, or yet more ancient ? In still older strata do the fossilized bones of an Ape more anthropoid, or a Man more pithecoid, than any yet known await the researches of some unborn palaeontologist?"

SECTION III (Notes)


1 Lartet, E. 1861. Nouvelles recherches sur la Coexistence de l'Homme et des grands Mammifères fossiles. *Ann. Sci. nat.* Paris (4, Zool.) **15** : 177–253, pls. 1–13.

2 Vallois, H. V. 1953. *In* Catalogue des Hommes Fossiles. *C. R. XIXe Sess. Congr. géol. int.*, Algers, 1952 : 162.

3 Lyell, C. 1873. *The Geological Evidence of the Antiquity of Man* : 129. 4th ed. London.

4 Campbell, B. 1956. The Centenary of Neanderthal Man. *Man*, London, **56** : 156–158, 1 fig.

5 Schaaffhausen, H. 1861. On the Crania of the Most Ancient Races of Man, translated by G. Busk. *Nat. Hist. Rev.*, London (n.s.) **1** : 155–172.

6 Huxley, T. H. 1863. *Evidence as to Man's Place in Nature* : 142. London.

7 Lyell, C. 1873. *The Geological Evidence of the Antiquity of Man* : 82. 4th ed. London.

8 Sollas, W. H. 1924. *Ancient Hunters* : 229. 3rd ed. London.

9 Oakley, K. P. 1963. Analytical Methods of Dating Bone. *In* Brothwell, D. R. & Higgs, E. S. *Science in Archaeology* : 24–34. London.

10 Huxley, T. H. 1863. *Evidence as to Man's Place in Nature* : 135. London.

11 Mayer, F. 1864. Über die fossilen Überreste eines menschlichen Schädels und Skeletes in einer Felsenhöhle des Düssel- oder Neander-Thales. *Arch. Anat. Physiol., Lpz.*, **1864** : 1–26.

12 King, W. 1864. On the Neanderthal Skull, or Reasons for believing it to belong to the Clydian Period, and to a Species different from that represented by Man. *Rep. Brit. Ass.* London, **1863,** Abstracts : 81.

By " Clydian Period " King meant the time represented by the marine clays containing arctic species of mollusca, which occur extensively in the Clyde district of Scotland. These beds were referred by James Geikie (1877) to the " Last Glacial Period ". Modern work has confirmed that Neanderthal Man attained his maximum development during the early part of the Last or Würm glaciation (see pp. 130–131).

The specific name *Homo neanderthalensis* dates from the publication of King's second paper (1864. The Reputed Fossil Man of Neanderthal. *Quart. J. Sci.*, London, **1** : 88–97) which gives an indication of some of the distinctive characteristics.

13 Busk, G. 1865. On a very Ancient Human Cranium from Gibraltar. *Rep. Brit. Ass.*, London, **1864,** Abstracts : 91–92.

Although no extinct mammalia were recorded in association with the skull, Busk remarked that the condition of the bone showed it was of great antiquity.

14 Campbell, B. 1956. The Centenary of Neanderthal Man. *Man*, London, **56** : 156, 171–173.

15 Keith, A. 1911. The Early History of the Gibraltar Skull. *Nature, Lond.*, **87** : 313.

It is interesting that Falconer in 1864 referred to the Gibraltar skull in these terms : " I do not regard this *priscan pithecoid man* as the 'missing link' so to speak. It is a case

of a very low type of humanity—very low and savage, and of extreme antiquity—but still man, and not a halfway step between man and monkey ". (*Palaeontolological Memoirs and Notes*, **2** : 561, footnote. Ed. C. Murchison, London, 1868).

16 Engis I child's skull discovered in 1830 and published by Schmerling in 1833 (*Recherches sur les ossements fossiles découvertes dans les cavernes de la province de Liége* : 62. Liège) ultimately proved to be Neanderthal, but was not recognized as such until 1936 (Fraipont, C. Les Hommes fossiles d'Engis. *Arch. Inst. Paléont hum.*, **16.** Paris).

17 Fraipont, J. & Lohest, M. 1887. Recherches ethnographiques sur les ossements humains découverts dans les dépôts quaternaires d'une grotte à Spy et détermination de leur âge géologique. *Arch. Biol. Paris*, **7** : 587–757.

18 Vayson de Pradenne, A. 1932. *Les Fraudes en Archéologie Préhistorique* : 65–101. Paris. See also Cole, S. 1955. *Counterfeit* : 121–127. London.

19 Delesse, A. 1863. La Mâchoire Humaine de Moulin de Quignon. *Mém. Soc. Anthrop. Paris*, **2** : 37–68.

20 Falconer, H. 1868. *Palaeontological Memoirs and Notes*, **2** : 601–625. Ed. C. Murchison. London.

21 Falconer, H. 1868 : 619.

22 Evans had been unable to attend the conference, but he revisited Abbeville at the end of May to see the evidence again. In his letter to the *Athenaeum* of June 1863 (p. 747) he said that of more than 150 flint implements in his own collection from the Somme gravels there was not one that did not present characteristics of antiquity ; whereas the " suspected *haches* have not one of these characteristics ", and when washed " their surface is as fresh as if made the same day. . . . Genuine implements ", he continued, " have been hitherto comparatively rare at Moulin-Quignon. The suspected implements are now found in abundance ".

Falconer has recorded (1868 : 612–613) that fabrication of counterfeit implements was actively being carried on at Abbeville and Amiens, to meet the lively demand among collectors of antiquities caused by the authentic discoveries made by Boucher de Perthes. Strangers were usually asked to pay 5 francs for the privilege of detaching from its gravel bed the *hache* professing to have been discovered in situ by the *terrasier*.

23 Keeping reported that on one occasion a workman pointed to an implement that he had just revealed. Keeping told him to stop digging so that he could remove it himself. " If the man had gone on digging the specimen out . . . I should most certainly have believed the specimen to have been a just one, as the gravel had not the appearance of having been recently removed ; but as soon as I commenced working I could tell directly that the gravel, for nearly the space of a foot round, had been moved, and I found the specimen near about in the centre of the new-made deposit ". (H. Keeping *in* Evans, J. *Athenaeum*, July 4, 1863 : 19.)

24 Falconer, H. 1868. *Palaeontological Memoirs and Notes*, **2** : 604. Ed. C. Murchison. London.

25 Prüner-Bey, F. 1866. Sur la mâchoire humaine de La Naulette. *Bull. Soc. Anthrop. Paris* (2) **1** : 584–592, 601–603.

26 Huxley, T. H. 1863. *Evidence as to Man's Place in Nature* : 159. London.

## IV. MIOCENE APES AND SPURIOUS " PLIOCENE MEN "

By the middle of the last century, largely through the active researches of the brilliant French lawyer turned palaeontologist, Edouard Lartet, some fossil " pithecoids " were in fact already known in Europe, but there was little disposition among the scientists of that time to see in these forms the possible progenitors of man. In 1837 Lartet[1] discovered in the Miocene deposits at Sansan (Gers) remains of an extinct ape-like form which appeared to be ancestral to the modern gibbons.

He named it *Pliopithecus*, from the Greek πλειων more and πιθηκος ape. In 1856 he obtained from similar calcareous sands of Miocene age at Saint Gaudens part of the lower jaw of a more advanced type of ape, which he named *Dryopithecus*,[2] and declared it to be closely akin to man. But remaining predominant was the idea that *Man, recognizable as such*, may have already existed in the Miocene period. Writing earlier of the finds at Sansan, Lartet expressed it thus :

" Here are represented various degrees in the scale of animal life, up to and including the Ape. A higher type, that of the human kind, has not been found here ; but we must not hastily conclude . . . that it did not exist ".[3]

In view of this climate of opinion, it is not surprising that serious consideration was continually being given to human skulls and skeletons of entirely modern type unearthed from deposits of Pliocene or even earlier age in various parts of the world.

In 1860 the Italian geologist Ragazzoni discovered some human skull fragments in a shelly marine clay of Pliocene age at Castenedolo in Liguria.[4] He could detect no indications that the overlying layers had been disturbed by the digging of a grave. Twenty years later, further remains were found in the same stratum : skeletons of a man, a woman and two children. Some of the bones were at a depth of over six feet below the present surface, and again the overlying layers appeared to be intact. The anatomist Professor G. Sergi who reported on these bones[5] was convinced that they constituted proof that *Homo sapiens* already existed in Pliocene times. To explain their occurrence in a marine stratum he had to assume the " shipwreck " of a Pliocene family. The skulls could easily be matched in a modern European population. Although the bones have not been tested by modern methods of relative dating, and although taken seriously by more than one anatomist in recent years, their conditions of preservation stamp them as unquestionably post-Pliocene burials. The skeleton of the woman was in a contracted posture. Moreover, Professor Issel's examination revealed the fact that all the various fossils in the stratum were impregnated by salt, with the sole exception of the human bones.[6]

English deposits too have yielded skeletal remains claimed at various times as evidence of the great antiquity of our species. In 1855, a human jawbone was found during the digging of coprolites[7] from the Red Crag sands at Foxhall, about four miles east of Ipswich. Heavily impregnated by iron oxides, the jaw matched the colour of the deposit in which it had lain, and was regarded by Dr. Robert Collyer, an American physician who described it in 1867,[8] as probably contemporaneous. At the time great interest was taken in the Foxhall jaw. It was the English equivalent of the Moulin-Quignon jaw. Strangely enough the two are almost identical morphologically[9] (Text-fig. 19). The Foxhall specimen shows on one side the rather rare feature of triple mental foramina[10] but could probably be matched in any sufficiently large series of modern human mandibles, although commoner in early populations than in later. Falconer,[11] commenting on the use of mineral criteria in assessing the antiquity of fossil bones, said that the Foxhall jaw " although retaining a portion of its gelatine, is infiltrated through and through with iron. The section of the cortical layer is dark, oxide of iron is seen filling the

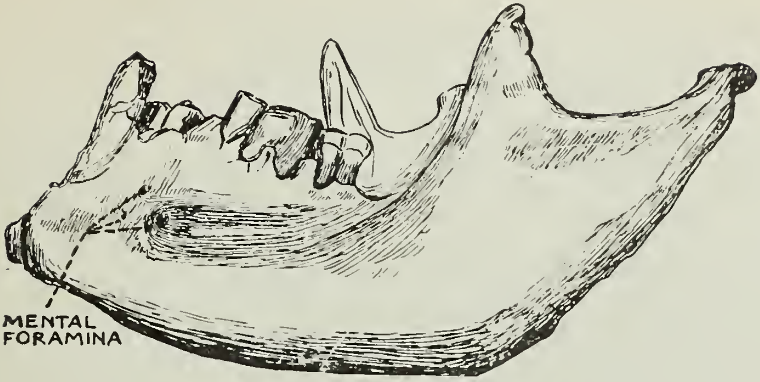



FIG. 19. The Foxhall jaw. *After Eiseley.* Nat. size. Whereabouts unknown.

Haversian canals ; a dark crust of the same material covers the walls of the cancelli ; coarse grains of sand, with red oxide of iron, line the walls of the dental canal ; and a vertical section of one of the fangs of a molar shows that the dentine is partly infiltrated by iron. The precise age of the jaw ", he said, " is unknown, but is conjectured not to exceed that of the Roman occupation of England ".

Interest in the Foxhall jaw was revived when Reid Moir advanced his claims to have found humanly chipped flints at the same level in the Foxhall sand-pit as the seam of nodules from which the " coprolite jaw " is alleged to have been extracted.[12] Collyer recorded that analysis of the jawbone showed that it contained 8 per cent. organic matter. Moir regarded this as consistent with the view that it was contemporaneous with the coprolite bed. He pointed out that fossil bones from the *basal* bed of the Red Crag are highly mineralized, with negligible organic content, but that those from the 16-ft. level in the Foxhall pit are commonly much less mineralized. He quoted analyses of five fossil bones from this level showing organic content ranging from 5·55 to 6·5 per cent. which he regarded as permitting him to regard the Foxhall jaw with 8 per cent. organic matter as possibly of Red Crag age.

We have already seen that the organic content of fossil bones is, considered by itself, very unreliable as a means of relative dating. It is unfortunate that the whereabouts of the Foxhall jaw is now unknown, in spite of energetic efforts to trace it in 1920,[13] for there is little doubt that by means of modern methods of relative dating its degree of antiquity could be established with some certainty. There are few students of the subject today who take seriously the possibility that this specimen is older than Neolithic.

The most ridiculous Pliocene pretender was the Calaveras Skull, on which Bret Harte wrote a poem :[14]

*Speak, thou awful vestige of the earth's creation,*
*Solitary fragment of remains organic!*
*Tell the wondrous secret of thy past existence—*
*Speak thou oldest primate!*

*Which my name is Bowers and my crust was busted*
*Falling down a shaft in Calaveras County,*
*But I'd take it kindly if you'd send the pieces*
*Home to old Missouri.*

In 1866 a miner named Mattison was working at a depth of about 130 feet in his gold mine at Table Mountain in Calaveras county, California, when he encountered in the seam of auriferous gravel a very odd-shaped lump covered with a crust of lime. He took it home as a curiosity and eventually the specimen fell into the hands of J. D. Whitney, State Geologist of California, who chiselled away the crust and revealed the greater part of a human cranium, with adhering matrix containing bits of charcoal and a shell bead. He took the skull to Harvard College where it was examined and described.[15] The skull had prominent cheek bones and was altogether quite typical of an American Indian (Text-fig. 20). Yet the gold-bearing stratum from which, allegedly, it came was of early Pliocene age, say more than 10 million years old. As Sir Arthur Keith once remarked, this made as much sense

FIG. 20. The Calaveras skull. *After T. Wilson.* $\times\frac{2}{3}$ nat. size. Peabody Museum, Harvard University. Cat. No. 74963.

as finding an aeroplane in a church crypt that had been bricked up since Elizabethan times. But it seems that nobody dared laugh, and the evidence relating to the "Auriferous Gravel Man" was thoroughly examined and severely criticized by W. H. Holmes,[26] while Aleš Hrdlička, searching the collection in the U.S. National Museum, found two comparatively recent skulls preserved in precisely the same way, with incrustation of stalagmite, which had been collected from old caves in Calaveras county in 1857.[17]

It is very probable that the whole affair started as a cowboy hoax, and that Mattison was the dupe.[18] It seems inconceivable now that it was ever taken seriously, but there was a strong subconscious desire to establish the antiquity of man in the New World, particularly in California where more than forty claims to have discovered early man have been advanced.[19] Even as late as 1900 the level-headed Thomas Wilson of the U.S. National Museum read a paper at the International Congress of Anthropology and Prehistoric Archaeology in Paris strongly defending the antiquity of the Calaveras skull, citing as supporting evidence the alleged finding of flint arrowheads and stone mortars (*metates*) in the auriferous gravels of the same region. To bring the matter quite up to date it should be mentioned that the Evolution Protest Movement in Britain complained in 1951[21] that the British Museum had suppressed important evidence by omitting all reference to the Calaveras skull from their handbook *The History of the Primates*, written by Sir Wilfrid Le Gros Clark.

It might be thought that the story of the Calaveras skull, entertaining though it is, would be scarcely worth mentioning in a survey of researches concerned with *dating* human remains. Curiously enough, however, as Sonia Cole has pointed out,[22] it has an unsuspected importance in that very connection. Wilson quoted in support of his thesis the results of chemical analyses of the skull and of a bone of an extinct rhinoceros from the auriferous gravel. The analyses,[23] rearranged below, showed

| | Calaveras skull % | | Bone of Rhinoceros hesperius % |
|---|---|---|---|
| Calcium phosphate | 39·79 | Calcium phosphate | 49·40 |
| Calcium carbonate | 62·03 | Calcium carbonate | 18·33 |
| Magnesium carbonate | 1·86 | Calcium fluoride | 4·77 |
| Silica | 1·44 | Silica | 22·70 |
| Iron oxide | 0·81 | Iron oxide | 4·58 |
| Water and organic matter | Traces | Magnesia | Traces |
| | 99·93 | | 99·78 |

that the skull and the extinct rhinoceros bone had both lost almost all their organic matter ("gelatine" of earlier writers), and that a large proportion of the bone of the skull had been replaced by calcium carbonate. Wilson argued on this basis that the Calaveras skull was "fossilized". In fact the percentages of the various minerals composing the two bones are very different. Moreover, as Holmes pointed out, under certain conditions bones can lose their organic matter in a few centuries; while if buried in limestone caves, where percolating waters are continually dissolving and redepositing calcareous matter, they may be replaced by calcium carbonate in a comparatively short time.

Vayson de Pradenne in his book on frauds published in 1932[24] drew attention to a feature of the Calaveras analyses which had previously been overlooked and which completely condemns Wilson's thesis. Vayson was apparently the first person in the present century to recognize the significance of Adolphe Carnot's discovery in the eighteen-nineties that the accumulation of *fluorine* in fossil bones provides a valuable means of relative dating. Looking again at the analyses of the Calaveras specimens we see that the genuinely fossil rhinoceros bone contains nearly 5 per cent. calcium fluoride, whereas the human skull contains none—" or no doubt traces which escaped the chemist ", to quote the cautious words of Vayson, who concluded : " There is thus no possible comparison between the ages of the two bones. One is geologically ancient, the other modern ".

SECTION IV (Notes)

1 Lartet, E. 1837. Note sur la découverte recente d'une mâchoire de singe fossile. *C. R. Acad. Sci.*, Paris, **4** : 91–92 ; 583–584.

2 Lartet, E. 1856. Note sur un grand Singe fossile qui se rattache au groupe des Singes supérieurs. *C. R. Acad. Sci.*, Paris, **43** : 219–223.
The name *Dryopithecus*, derived from the Greek words δρυς oak tree and πιθηκος ape, was used because fossil oak leaves were found in the Miocene deposits containing remains of this ape.

3 Boule, M. & Vallois, H. V. 1957. *Fossil Men* : 17, 18. London. Also see Fischer, P. 1872. Note sur les travaux scientifiques d'Edouard Lartet. *Bull. Soc. géol. Fr.*, Paris (2) **29** : 252.

4 Ragazzoni, G. 1880. La collina di Castenedolo. *Commentari dell'Ateneo di Brescia* : 120. Brescia.

5 Sergi, G. 1884. L'Uomo Terziario in Lombardia. *Arch. Antrop. Etnol.*, Firenze, **14** : 303–318, pl. 1.

6 Issel, A. 1889. Cenni sulla giacitura dello scheletro umano recentemente scoperto nel Pliocene de Castenedolo. *Boll. Paletnol. ital.*, Parma, **15** : 89.

7 Coprolites, *sensu stricto*, are fossilized excreta, but this name (derived from κοπρος dung) has been applied also to brown or black phosphatic nodules of similar appearance, but of inorganic origin, formed on the sea-floor. Such are the " coprolites " in the Red Crag of Suffolk. The Crag " coprolites " with associated fossil bones and teeth were extracted commercially during the last century from 1847 onwards. Ground down and treated with sulphuric acid these materials became superphosphate fertiliser for the land. See Oakley, K. P. 1944. Man and the Migrations of Phosphorus. *Trans. S.E. Union Sci. Soc.*, London, **49** : 29, 30.

8 Collyer, R. H. 1867. The Fossil Human Jaw from Suffolk. *Anthrop. Rev.*, London, **5** : 221.

9 Keith, A. 1925. *The Antiquity of Man*, **1** : 273. London.

10 Eiseley, L. C. 1943. A Neglected Anatomical Feature of the Foxhall Jaw. *Trans. Kans. Acad. Sci.*, Topeka, **48** : 57–59.

11 Falconer, H. 1868. *Palaeontological Memoirs and Notes*, **2** : 616. Ed. C. Murchison. London.

12 Reid Moir, J. 1921. Further Discoveries of Humanly-fashioned Flints in and beneath the Red Crag of Suffolk. *Proc. Prehist. Soc. E. Angl.*, London, **3** : 390–411.

13 Reid Moir, J. 1921 : 397.

14 Bret Harte. 1887. To the Pliocene Skull. *Complete Poetical Works* : 256–257. London.

[15] Whitney, J. D. 1879. The Auriferous Gravels of the Sierra Nevada of California. *Mem. Harv. Mus. Comp. Anat.*, Cambridge, Mass., **6** : 258–288.
[16] Holmes, W. H. 1899. A Review of the evidence relating to the Auriferous Gravel Man in California. *Rep. Smithson. Instn.*, Washington, **1899** : 419–472.
[17] Hrdlička, A. 1907. Skeletal Remains suggesting or attributed to Early Man. *Smithson. Inst. Bur. Ethn.*, Washington, **33** : 21–28.
[18] Cole, S. 1955. *Counterfeit* : 133. London.
[19] Heizer, R. F. 1950. Observations on Early Man in California. *Rep. Arch. Surv. Univ. Calif.*, Los Angeles, **7** : 5–9.
[20] Wilson, T. 1902. La haute ancienneté de l'homme dans l'amérique du Nord. *C. R. Congr. Int. Anthrop. Arch. Préhist.*, Paris (XIIe sess., 1900) : 158–170.
[21] Filmer, W. E. 1951. How They Choose Our Ancestors, A Protest to the Trustees of the British Museum. *Evolution Protest Movement.* 11 pp. London.
[22] Cole, S. 1955. *Counterfeit* : 134. London.
[23] Analyses by Sharples, and originally published by Whitney (1879 : 244, 269—see Note 15).
[24] Vayson de Pradenne, A. 1932. *Les Fraudes en Archéologie Préhistorique* : 142, footnote. Paris.

## V. CRO-MAGNON AND OTHER FOSSIL MEN : THE PALAEOLITHIC SEQUENCE

Looking back over the history of human palaeontology, it is strange to find that when genuine fossil men were discovered, doubts about them were sometimes as persistent as the mistaken beliefs in spurious specimens. The recurring prejudice against the Pleistocene men of Cro-Magnon is a case in point.

In 1868, when the railway from Périgueux to Agen was being constructed through Les Eyzies in the Vézère valley (Dordogne), clearance of material from the hillside revealed an *abri* or rock-shelter containing layers of occupation debris, crammed with bones and teeth of reindeer and other animals of the glacial fauna, together with Palaeolithic artifacts in flint and bone. Full excavation of this site, known as Cro-Magnon,[1] was undertaken by the geologist Louis Lartet,[2] son of the eminent Edouard. At the back of the *abri*, below a ledge of rock and completely sealed in by ancient rock-falls (Text-fig. 21), he found a layer containing remains of five human skeletons referable to our own species *Homo sapiens*. These had evidently been buried ceremonially, for they were accompanied by red ochre and by strings or necklaces of sea shells (*Littorina*). Although the skeletons were at the top of the deposits with Palaeolithic implements and food refuse, the layer which contained them " included an unbroken series of hearths which actually touched the overhanging rock except for a short space at the very back ".[3] There was no doubt in the mind of the excavator that the skeletons had been interred during Pleistocene times. Yet, Boyd Dawkins,[4] one of the leading authorities in Britain at that time on cave deposits, wrote in 1880 that the remains of Cro-Magnon Man were in a deposit *overlying* the ancient refuse heaps, and were " therefore later than the Palaeolithic ". While in 1895, the eminent French prehistorian Gabriel de Mortillet, to whom we owe the basic classification of Old Stone Age cultures, stated categorically in regard to the Cro-Magnon skeletons : " il est facile de montrer qu'elles sont recentes ".[5] To his mind one of the indications that they were Recent was the act that the skull of the " Old Man " (Plate 2) protruded from the deposits into

f

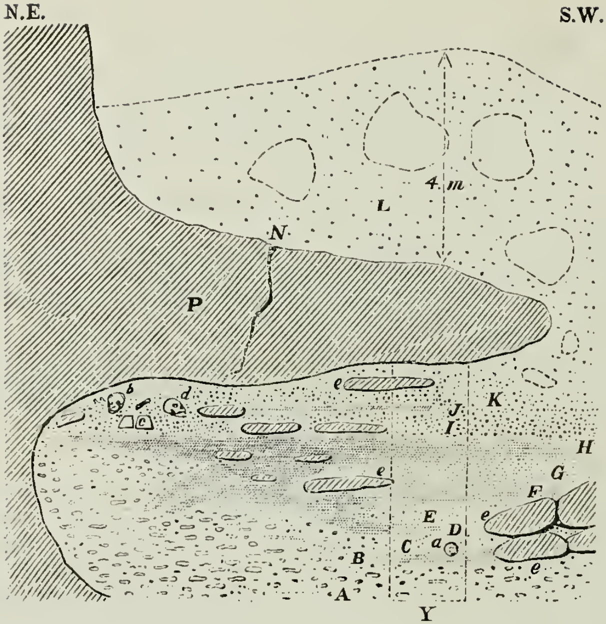



FIG. 21. Section through the Cro-Magnon rock-shelter. *After L. Lartet* (in E. Lartet & Christy). A, C, E, K, debris of the soft limestone ; B. D. F. layers of ashes (hearths) ; G, red earth with bones ; H, thickest layer of ashes, with animal bones and flints ; I, yellowish earth with bones and flints ; J, thin bed of hearth material ; P, projecting roof of hard limestone ; *a*, elephant tusk ; *b*, bones of " Old Man " [Cro-Magnon I] ; *c*, block of gneiss ; *d*, human bones ; *e*, roof falls.

the vacant space, and judging from a patch of stalagmitic incrustation, and from the corroded state of the facial bones, it had never been completely covered by Palaeolithic debris. To reassure the reader that this is not necessarily a valid reason for doubting the antiquity of bones, it is worth recalling that a *Neanderthal* skull was found in a precisely similar uncovered state on the floor of one of the caves in Monte Circeo. As a further supposed indication that the Cro-Magnon burials were Recent, de Mortillet pointed out that the associated *Littorina* shells had retained their " epidermal " colour. However, it is now well known that shell-pigments are sometimes remarkably persistent. The fossil shells of *Theodoxus* in the Lower Palaeolithic gravels at Swanscombe, for instance, have retained their colour pattern.

It was agreed by all that the skeletons in question were Stone Age *burials :* the differences of opinion related simply to the date of interment. It may be that de Mortillet was prejudiced against accepting them as Palaeolithic simply because he had for long been firmly convinced that no ceremonial burials were older than Neolithic.[6]

Even as recently as 1924 Grant MacCurdy allowed a hint of scepticism about their dating to creep into his account of the Cro-Magnon skeletons, saying[7] " The . . . remains look as fresh as if they had been found in cave deposits of Neolithic age " and furthermore " In some respects . . . do resemble the early Neolithic races more closely than do certain Aurignacian [i.e. late Palaeolithic] skeletons of which the age is beyond question ". At the present day, the Cro-Magnon remains are unreservedly accepted as Palaeolithic by those best qualified to judge the evidence,[8] but if doubts ever recurred radiocarbon dating should provide an objective indication of their actual age (see p. 150).

Appreciation of the significance of the fossil human remains that eventually passed muster depended to a considerable extent on the building up of a framework of relative chronology into which the various finds could be fitted. Especially important in this connection were the researches of Edouard Lartet in the caves of the Dordogne in south-western France, where he was assisted by the banker Henry Christy in 1863 and 1864. Their excavations in the caves or rock-shelters of Laugerie Haute, Les Eyzies, Le Moustier and La Madeleine showed that the " Age of simply worked stone ", or as we would now say Palaeolithic period, was not a single phase of human culture, but a succession of phases, which were locally datable by the associated fossil animal remains, on the principle that the composition of the fauna changed in course of time. On the basis of the finds in the Dordogne caves, Lartet had proposed in 1860 to distinguish the following periods :[9]

(4) Period of Aurochs (*Bos primigenius*), early Post-Pleistocene in modern terms

(3) Reindeer Period, = Late Pleistocene in modern terms

(2) Period of Mammoth (*Elephas primigenius*) and Woolly Rhinoceros, '*Rhinoceros tichorhinus*' [= *Coelodonta antiquitatis*]

(1) Cave-bear Period.

Later he recognized that the Cave-bear and Mammoth periods were scarcely separable ; while another palaeontologist, Garrigou,[10] pointed out that these periods, when glacial or cold-tolerant animals predominated, were preceded by times when the fauna had a warm aspect, and included such forms as *Hippopotamus*, *Elephas* (*Palaeoloxodon*) *antiquus* and Merck's rhinoceros (*Dicerorhinus kirkbergensis*). In the eighteen-seventies James Geikie and others realized that the river-drifts with this warm fauna and Palaeolithic hand-axes, as at Abbeville and St. Acheul in the Somme valley, represented one or more *interglacial* periods.

Some students of the Palaeolithic in Lartet's day disagreed with his use of faunal subdivisions of prehistoric times. They pointed out that the incidence of the various animal species would have varied from region to region, and that the differences between the contents of one Palaeolithic occupation deposit and another might simply reflect the preferences of different groups of hunters. These criticisms had elements of truth in them, but the discovery of the same broad faunal succession at site after site eventually proved that, within certain limits, fossils provide a good basis for subdivision of the Pleistocene period.

Archaeologists such as Gabriel de Mortillet considered that it was better to subdivide the Palaeolithic period into stages based on the various types of artifact which successively prevailed in Western Europe. In 1867, de Mortillet[11] developed a scheme of relative chronology based on the sequence of Palaeolithic industries found in France. The stages or " epochs " were named after the sites where the industries were typically represented, as follows :—

Époque de la Madeleine (= Reindeer Age)
Époque de Solutré
Époque d'Aurignac
Époque du Moustier (= early part of Cave-bear–Mammoth Age)
Époque de Chelles (= period of *Elephas antiquus*).

De Mortillet was uncertain where the Aurignacian epoch should be placed. At first (in 1867) he followed Lartet's suggestion and placed it late in the Cave-bear–Mammoth Age ; next (in 1868) he placed it *after* Solutré, and then finally (in 1872), dropped it out of his scheme altogether.

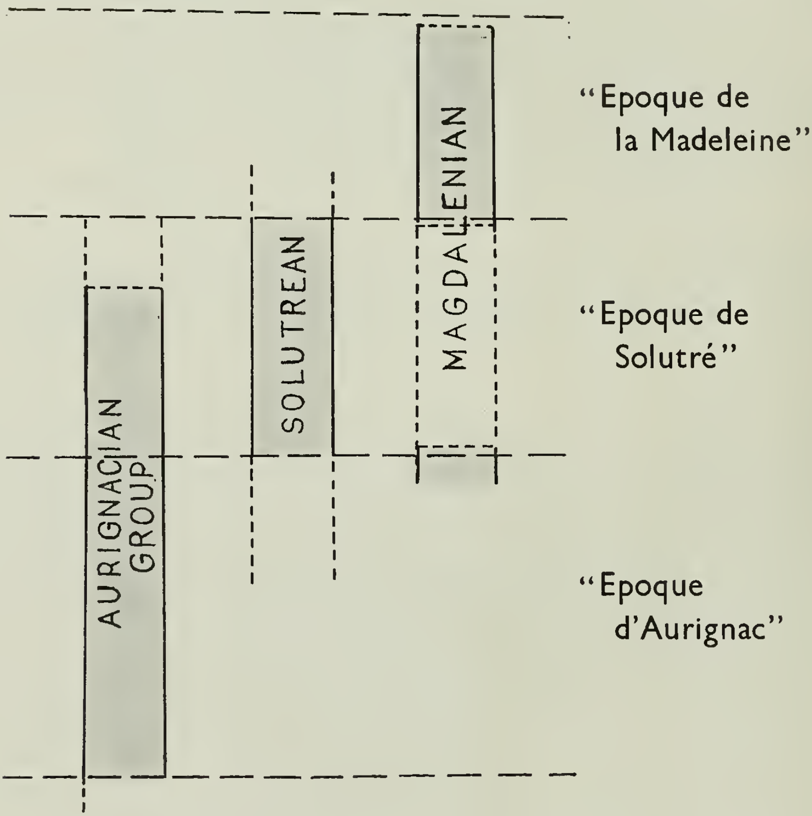



FIG. 22. Time relationships of the main Upper Palaeolithic culture-groups.

When the names Chellean, Mousterian, Aurignacian and so on were introduced, they were unquestionably intended as the names of *periods*,[12] but during the present century they have acquired a different significance, and have been mainly used as the names of *cultures*.

This change occurred through evidence accumulating, as research extended over wider areas, which showed that the Palaeolithic industries named in de Mortillet's scheme did not follow one another in a simple linear series, but were manifestations of separate cultural traditions which were in part contemporaneous (Text-fig. 22). Thus, although the Aurignacian culture began before the Solutrean, Late Aurignacian industries are geologically younger than Early Solutrean. Hamy,[13] writing in 1870, was the first to recognize that Solutrean and Magdalenian cultures were largely contemporaneous.

In spite of these complications, the following classification, of the broad cultural subdivisions of the Palaeolithic in Western Europe, was generally agreed within the first decade of the present century :

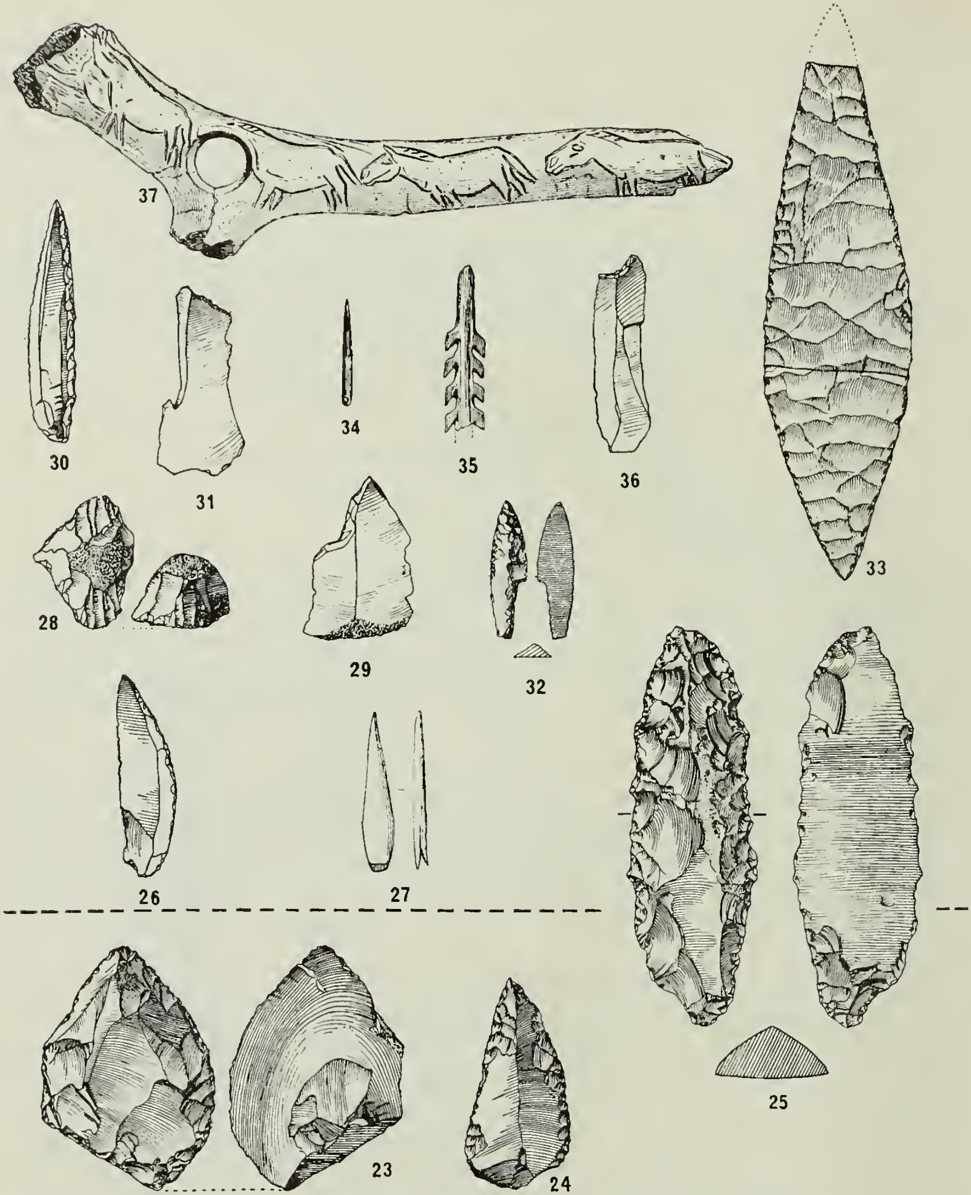
| | |
|---|---|
| Magdalenian | |
| Solutrean | Upper Palaeolithic |
| Aurignacian | |
| Mousterian | — Middle Palaeolithic |
| Acheulian | Lower Palaeolithic. |
| Chellean | |

The Lower Palaeolithic, or River Drift period, when men lived mainly in the open, is represented almost entirely by implements chipped in stone. The artifacts usually regarded as most characteristic of this period are "core-tools",[14] that is to say made by striking flakes from a nodule or pebble so that the residual core forms the implement. Such are the typical Chellean and Acheulian hand-axes (Text-figs. 4, 8–10), called *haches* or *coups de poing* by the earlier French archaeologists.

In the succeeding Middle Palaeolithic period, men sometimes lived in the open, but when the climate became severe they took to making their homes in shallow caves or rock-shelters. The Middle Palaeolithic stage, represented by the Mousterian industries, was distinguished by the frequency with which tools were chipped out of *flakes* (Text-figs. 23, 24). Although bones were occasionally used (for example as anvils), no attempt was made in this stage to work them into implements or to decorate them.

In Upper Palaeolithic cultures, flint tools were mostly made on parallel-sided flakes, or *blades* (Text-figs. 26, 30, 36), while bone, antler and ivory were extensively worked (Text-figs. 6, 27, 34, 35, 37). Many groups of hunters of this period occupied caves, or rock-shelters. They were responsible for the well-known cave-art of southern France and Spain. Other groups, wherever conditions were suitable, lived in huts or tents in the open. The type-station of Solutrean culture (Text-fig. 33), near Macon in south-east France, is an example of one of these open sites. Some of the mammoth and reindeer hunters living on open sites in Eastern Europe carved and engraved ivory and other bony materials with remarkable artistry.

Particularly important from the point of view of using artifacts for relative dating is the question of the chronological relationship of the Palaeolithic cultures to the faunal and climatic stages of the Pleistocene, in other words the dating of the Early Stone Age or Palaeolithic cultures in terms of glacial and interglacial periods. James




FIGS. 23–37. Representative Middle and Upper Palaeolithic artifacts, arranged stratigraphically. Those below the broken line are Middle Palaeolithic, those above Upper Palaeolithic. "Proto-Solutrean" is in Middle Upper transition. × *circa* $\frac{2}{3}$ nat. size.

FIG. 23. Mousterian side-scraper on a flake of flint. Le Moustier rock-shelter, near Peyzac (Dordogne). B.M. (N.H.) E.322*a*.

FIG. 24. Mousterian point on flake (flint). Le Moustier rock-shelter. B.M. No. E.324.

FIG. 25. "Proto-Solutrean" (cf. Szeletian) flint point. Nietoperowa Cave, Jerzmanowice, Ojcow district, Poland. B.M. (N.H.) E.202.
FIG. 26. " Lower Aurignacian " (Châtelperronian = Earlier Perigordian) flint knife-point. Châtelperron. B.M. (N.H.) E.1217.
FIG. 27. " Lower Aurignacian " (Châtelperronian) split-base bone point. Sergeac (Dordogne). *After Peyrony.*
FIG. 28. " Middle Aurignacian " (Aurignacian *s.s.*) flint end-scraper. Cae Gwyn, Vale of Clwyd, N. Wales. B.M. (N.H.) E.1318.
FIG. 29. " Middle Aurignacian " (Aurignacian *s.s.*) flint *burin busqué.* Cro-Magnon (Dordogne). B.M. (N.H.) E.1306.
FIG. 30. " Upper Aurignacian " (Gravettian = Later Perigordian) flint knife-point. Laussel (Dordogne). B.M. (N.H.) E.1218.
FIG. 31. " Upper Aurignacian " (Gravettian) flint graver or burin. Langerie Haute (Dordogne). B.M. (N.H.) E.1320.
FIG. 32. Solutrean shouldered " willow-leaf " flint point, showing pressure-flaking. Bourdeilles (Dordogne). B.M. (N.H.) E.1331.
FIG. 33. Solutrean " laurel leaf " bifacial flint blade. Solutré, France. *After de Mortillet.*
FIG. 34. Magdalenian polished bone needle. Bruniquel Caves (Tarn-et-Garonne). B.M. (N.H.) 39306.
FIG. 35. Magdalenian-type biserially barbed point in antler. Kent's Cavern, Torquay. B.M. (N.H.) E.70.
FIG. 36. Magdalenian concave flint end-scraper. Limeuil (Dordogne). B.M. (N.H.) E.1321.
FIG. 37. Magdalenian antler tool ; perforated and decorated with incised horses. La Madeleine rock-shelter (Dordogne). *After de Mortillet.*

Geikie began to deal with this question to some extent in his work on the Great Ice Age. In the second edition (1877) he noted the possibility that human origins were preglacial, but in the next edition (1894), in spite of the current clamours of believers in eoliths, he stated[15] that there was still no acceptable evidence that man was an inhabitant of Europe either before or during the First Interglacial period, when the characteristic elephant was *Elephas* (*Archidiskodon*) *meridionalis.* He pointed out that in contrast there were abundant traces of man in the form of Chellean and Acheulian hand-axes associated with remains of *Elephas* (*Palaeoloxodon*) *antiquus*, dating from the succeeding interglacial.

There was for a long time much confusion—there still is some—between deposits of the Second and the Third interglacial periods, partly due to the fact that *Elephas* (*Palaeoloxodon*) *antiquus*, mainly characteristic of the Second, persisted in some areas into the Third Interglacial. Perhaps through this confusion, Geikie fell into the error of mistaking certain events of the Fourth Glaciation for events of the " Third ". Thus in 1894[16] he attributed the main occupation of the French caves to the time of the " Third ", whereas in fact they had been mainly occupied, as he later recognized, during the Fourth or last main glaciation. On the other hand he had already correctly inferred[17] that the later Palaeolithic men were hunting mammoth (*Elephas* (*Mammuthus*) *primigenius*) and reindeer during the time of formation of the Younger Loess, a deposit of wind-borne dust which blanketed extensive areas of Europe and Asia under the steppe conditions that prevailed during certain phases of the Last Glaciation.

For a number of years there was considerable uncertainty about the correlation of the Mousterian stage of culture with the glacial-interglacial sequence. W. H. L. Duckworth said in 1912:[18] " In attempting to adjust the scale of glacial periods to that provided by the succession of implements, it is suggested that a commencement should be made by considering the period designated Mousterian. If the position of the Mousterian period can be correlated with a definite subdivision of the Ice Age, the other periods will fall into line mechanically ".

The geologists Penck & Brückner found evidence early in this century[19] that there had been four distinct extensions of ice over the foreland of the Alps, and these they named after the Bavarian valleys where the respective moraines and outwash gravels were well developed, in order of time : Günz, Mindel, Riss and Würm. These were presumed to be the First, Second, Third and Fourth Glaciations already recognized by Geikie.[20]

Emil Bächler reported in 1906[21] that the cave of Wildkirchli at 4,923 feet above sea-level in the Swiss Alps had been occupied by Mousterian Man at a time when the fauna of the area was of temperate type, although it did not include any definite time indicator such as *Elephas* (*Palaeoloxodon*) *antiquus*. As the entrance to the cave was above the snow-line of the Würm ice-age, Penck[22] inferred that Mousterian Man had occupied it during the preceding, Riss-Würm interglacial period. At a number of other localities, for example at Spy in Belgium, and in many French caves, Mousterian industries had been found associated with an arctic or tundra fauna including mammoth (*Elephas* (*Mammuthus*) *primigenius*), woolly rhinoceros and reindeer. Penck and some other authorities[23] regarded the main or " cold " Mousterian as dating from the Third Glaciation ; but as it directly underlay Aurignacian layers at many of the sites, there was really no doubt that it dated from the early stage of the Fourth, or Würm, glaciation.

The term Mousterian was formerly used by archaeologists much more widely than at present, and covered flake industries which are now known as Clactonian and Levalloisian. Some of these Mousterian-like industries were being made during and before the Third Glaciation. However, even in the restricted sense, Mousterian culture certainly existed during Third Interglacial times. For example, at Taubach near Weimar, Mousterian artifacts had been discovered in 1895[24] associated with remains of *Elephas* (*Palaeoloxodon*) *antiquus*, also with two human teeth which gave rise to much discussion on account of certain ape-like traits. The Taubach teeth are now recognized as representing a variant of the Neanderthal type.

There is no longer any doubt that the " cold " or main Mousterian industries date from the first part of the Fourth Glaciation, and that some " warm " Mousterian belonged to Third Interglacial times. However, the possibility that some of the " warm " Mousterian in Southern Europe (for example at Krapina in Yugoslavia) were really contemporaneous with an early interstadial of the Fourth Glaciation still has to be considered.

In 1873,[25] Merck discovered in the cave of Kesserloch, in Switzerland, numerous Palaeolithic artifacts, including engraved reindeer antlers, which were later identified as Magdalenian. Penck[26] showed that this occupation of the cave occurred during the retreat of the ice in the final stage of the Last Glaciation.

By the end of the first decade of this century, although there were many and varying interpretations of the evidence, it was beginning to be recognized that the cultures of Palaeolithic Man were probably datable geologically as follows :—

| | |
|---|---|
| Last glaciation (= Würm) | Magdalenian<br>Solutrean<br>Aurignacian<br>Mousterian |
| Third Interglacial (= Riss-Würm) | Mousterian<br>Late Acheulian |
| Third Glaciation (= Riss) | |
| Second Interglacial (Mindel-Riss) | Early Acheulian<br>Chellean<br>Pre-Chellean<br>(Strepyan,[27] Mesvinian) |

Although the increase of our knowledge of the Palaeolithic in the last fifty years, particularly through the extension of research beyond Europe, has greatly complicated the picture, the sequence of culture stages established in France in the last century provided a useful provisional scheme of relative chronology for almost all the fossil men then known. The following archaeologically dated remains, among others, had been reported before World War I :

| | |
|---|---|
| Magdalenian : | La Madeleine (1864) ; Bruniquel (1863–64) ; Laugerie Basse (1872) ; Chancelade (1888). *Homo sapiens.* |
| Solutrean : | Le Placard (1882) ; Pair-non-Pair (1888). *Homo sapiens.* |
| Aurignacian : | Engis II (1830) ; Cro-Magnon (1868) ; Brunn II (1891) ; Predmost (1894) ; Grimaldi (1902–06) ; Combe Capelle (1909). *Homo sapiens.* |
| Mousterian : | Sipka (1880) ; Spy (1886) ; Taubach (1887, 1892) ; Krapina (1899) ; Le Moustier (1908) ; Ehringsdorf (1908) ; La Chapelle-aux-Saints (1908) ; La Ferrassie (1909). *Homo neanderthalensis.* |

Thus, in the early part of this century it seemed clear enough that, if one excluded remains of doubtful age such as the skeleton found with Acheulian hand-axes at Galley Hill in 1888,[28] the earliest relics of our own species, *Homo sapiens*, were Upper Palaeolithic. It seemed equally clear that *Homo neanderthalensis* was Middle Palaeolithic. The question of the nature of the precursors of these two species presented a great problem, and the evidence bearing on it fifty years ago was puzzling and of very unequal value.

SECTION V (Notes)

1 In *patois*, cro magnon means great hole. The rock-shelter is now occupied by part of the hotel named after it.

2 Lartet, L. 1868. A Burial Place of the Cave-dwellers of Perigord, *in* Lartet, E. & Christy, H. *Reliquae Aquitanica*, **6** : 62–72. Ed. T. R. Jones. London.

3 MacCurdy, C. G. 1924. *Human Origins*, **1** : 381. New York.

4 Dawkins, W. B. 1880. *Early Man in Britain* : 206–207. London.

5 Mortillet, G. & A. de. 1900. *Le Préhistorique* : 312. 3rd ed. Paris.

6 Sollas, W. J. 1924. *Ancient Hunters* : 446. 2nd ed. London.

7 MacCurdy, C. G. 1924. *Human Origins*, **1** : 382–383. New York. F. Pruner-Bey has left it on record that before treatment the human bones were tested for gelatine content, which proved to be the same as that of Palaeolithic reindeer bones at this site (Lartet & Christy. 1868. *Reliquae Aquitanicae*, **7** : 73).

8 Vallois, H. V. 1952. Catalogue des Hommes Fossiles. *C. R. Congr. Géol. Int.* (XIXe sess., Algers) 1952 : 132. The archaeological horizon of the Cro-Magnon skeletons is stated to be " Aurignacien-niveau des pointes à base fendue ". (For dating of Aurignacian remains see p. 150.)

9 Lartet, E. 1860, quoted in *Bull. Soc. Anthrop. Paris*, **6** (1865) : 334.

10 Garrigou, F., quoted by Daniel, G. E. 1950. *A Hundred Years of Archaeology* : 100. London.

11 In *Matériaux de l'Histoire positive et naturelle de l'Homme*, 3 (1867) : 193–195. G. de Mortillet regarded the stage of culture represented at Laugerie Haute as *following* that represented at Aurignac, which he placed with the stage of Le Moustier in " première époque des cavernes ". A year later (1868, 4 : 457) he proposed the name " Époque de Solutré " as the equivalent of " Époque de Laugerie Haute " but regarded it as coming *before* Époque d'Aurignac. In his later classification (1872 *C. R. Int. Anthrop. Arch. préhist.*, Bruxelles (VIe sess.) : 442–443) he eliminated the Aurignacian epoch altogether. Many authors at the end of the last century and beginning of the present followed de Mortillet in limiting the Palaeolithic stage-names to Chellean, Mousterian, Solutrean and Magdalenian.

12 Daniel, G. E. 1950. *A Hundred Years of Archaeology* : 106, 108–109. London.

13 Hamy, E. T. 1870. *Précis de Paléontologie Humaine* : 336–340. Paris.

14 It is evident from William Pengelly's address on the Antiquity of Man (*Rep. Brit. Ass.*, **1883** : 558) that he was the first archaeologist to classify Palaeolithic industries on the basis of distinction between core-tools and flake-tools. Thus, speaking of the stone artifacts from Kent's Cavern, he said : " While all . . . are Palaeolithic . . . a mere inspection shows that they belong to two distinct categories. Those found in the Breccia—that is to say the more ancient—were formed by chipping a flint nodule or pebble into a tool, while those of the Cave-earth—the less ancient series—were fashioned by first detaching a suitable flake from the nodule or pebble, and trimming the flake—not the nodule—into a tool ".

15 Geikie, J. 1894. *The Great Ice Age* : 689. 3rd ed. London.

16 Geikie, J. 1894 : 690.

17 Geikie, J. 1894 : 689.

18 Duckworth, W. H. L. 1912. *Prehistoric Man* : 118. Cambridge.

19 Penck, A. & Brückner, E. 1900. *Die Alpen im Eiszeitalter*. 3 vols. Leipzig.

20 In his Munro Lectures (Geikie, J. 1913. *On the Antiquity of Man in Europe*) he gave a revised version of a classification of glacials and interglacials which he had proposed in 1895 (*J. Geol.*, Chicago, **3** : 241) and correlated it with the scheme later put forward by Penck & Brückner, as follows :

| | |
|---|---|
| Scanian or 1st Glacial . . . . . . | — Günz |
| Norfolkian or 1st Interglacial . . . . | — Günz-Mindel |
| Saxonian or 2nd Glacial . . . . . . | — Mindel |
| Tyrolian or 2nd Interglacial . . . . | — Mindel-Riss |

| | | |
|---|---|---|
| Polonian or 3rd Glacial . . . . . | — | Riss |
| Durnentian or 3rd Interglacial . . . | — | Riss-Würm |
| Mecklenburgian or 4th Glacial . . . . | — | Würm |
| Lower Forestian or 4th " Interglacial " . . | | "Post-Würmian" |
| Lower Turbarian or 5th " Glacial " . . . | | retreats |
| Upper Forestian or 5th " Interglacial " . . | | and |
| Upper Turbarian or 6th " Glacial " . . . | | advances |

Geikie's use of names for the interglacial stages had much to recommend it.

[21] BÄCHLER, E. 1906–07. Die prähistorische Kulturstätte in der Wildkirchlieben-Alphöhle (Säntisgebirge, *Verh. schweiz. naturf. Ges.*, St. Gallen).

[22] PENCK, A. & BRÜCKNER, E. 1909. *Die Alpen im Eiszeitalter.* 3 vols. Leipzig.

[23] DUCKWORTH, W. H. L. 1912. *Prehistoric Man* : 120. Cambridge. For discussion.

[24] NEHRING, A. 1895. Über Kinderzahn aus dem Diluvium von Taubach bei Weimar. *Z. Ethn.*, Berlin, **27** : 425–433. See also Keith, A. 1925. *Antiquity of Man*, **1** : 191. London.

[25] MERCK, C. 1876. *Excavations at the Kesserloch near Thayngen, Switzerland* (translated from German by J. E. Lee). London.

[26] PENCK, A. 1901. Die Glacialbildungen um Schaffhausen und ihre Beziehungen zu den praehistorischen Stationen des Schweizersbildes und von Thayingen. Reprinted from *N. Denkschr. schweiz. naturf. Ges.*, Zurich, **35** (1896).

[27] The name Strepyan was applied by Rutot to simply-flaked nodule tools found in certain terrace gravels in Belgium, and regarded by him as prototypes of the Chellean industry, comparable with the Pre-Chellean recognized by V. Commont in the Somme Valley. From gravels of similar age at Mesvin, Rutot described flake-tools which foreshadowed the Mousterian, but which were " eolithic " in their crudity. The " Mesvinian " industry, subject of much controversy (Sollas, W. J. 1924. *Ancient Hunters* : 157), was eventually identified with the better defined flake-industry found in the *Elephas* (*Palaeoloxodon*) *antiquus* gravel at Clacton-on-Sea, Essex, and named Clactonian by Hazzledine Warren (*Trans. S.E. Union Sci. Soc.*, London, **1926** : 47, footnote). Much of the Pre-Chellean, and the Chellean industries, were eventually classed as phases of Acheulian culture.

[28] The evidence for the antiquity of the Galley Hill skeleton was re-examined in 1948. The suggestion that it had been buried in the Swanscombe gravel in post-Pleistocene times was confirmed by comparison of its *fluorine* content with that of a series of fossil bones from local Pleistocene deposits (Oakley, K. P. & Montagu, M. F. A. 1949. *Bull. Brit. Mus.* (*Nat. Hist.*) *Geol.*, **1** : 25–48). In 1960, after nitrogen analysis had established the percentage of residual collagen in this skeleton, portions of the humeri were found to be adequate for determining the radiocarbon age of this " historic " specimen (see p. 150) now preserved (with accurate casts of the expended portions) in the Anthropology Sub-Department of the British Museum (Natural History).

## VI. DATING THE EARLIEST MEN : JAVA AND HEIDELBERG

The filling of the big blank between Middle Palaeolithic or Neanderthal Man on the one hand and the Tertiary apes on the other, began in the eighteen-nineties through the compulsive zeal of a young Dutch army doctor, Eugene Dubois, who had been inspired by the writings of Darwin and other evolutionists, and regarded the tropics as the area in which we may expect to find the fossilized precursors of man.[1] Posted to the Dutch East Indies as an army physician in 1887, he found an opportunity to excavate caves in Sumatra, and later was commissioned to make a reconnaisance of fossil-bearing deposits in Java. Collecting from ancient river gravels at Kedung Brubus in Central Java, he discovered on November 24th 1890 a fragment of a fossilized human jawbone.[2] Unfortunately it was undiagnostic, lacking the chin region and the teeth, apart from the root of one of the canines, or eye-teeth ; but it was an encouraging find, for the same deposits yielded remains of animals now extinct in Java, such as the tapir.

Next year, continuing westwards up the valley of the Bengawan, or Great Solo River, Dubois reached some promising exposures of volcanic tuffs and sands near the river-side village of Trinil a few miles from the foot of the volcano Mt. Lawu. It was then August, late in the dry season when the river is at its lowest, and consequently Dubois was able to dig into a bone-bearing layer which was often inaccessible through flooding. His search was soon rewarded by discovering among the fossils brought out of the excavations by his workmen an upper molar tooth of ape-like form (Text-fig. 38, *right*) which he provisionally identified as *Anthropopithecus*[3]—the Latin name then in use for chimpanzee. Although chimpanzees are confined to Africa, this identification did not seem unreasonable at the time because a fossil jaw fragment of an ape[4] similar to chimpanzee had been discovered in the Late Tertiary deposits of the Siwalik Hills in N.W. India, and Dubois was of the opinion that there were close faunal connections between Java and India.

Continuing the excavations at Trinil in the following month (September 1891) Dubois obtained from the same deposit the top of a low-vaulted skull with prominent brow-ridges, and this he also regarded at first as belonging to chimpanzee and reported it as such in his quarterly report to the Mining Authority. This specimen was in fact the famous Java Skull (Text-fig. 39).

Resuming excavations at Trinil in the dry season of the following year, Dubois discovered in the same ashy layer a lower premolar tooth (Text-fig. 38, *left*), obviously hominoid, and—fifty feet away from the previous find—a femur (thigh-

FIG. 38. Trinil teeth : premolar (*Pithecanthropus*), molar (*Pongo*). Nat. size.

FIG. 39. Calvaria of *Pithecanthropus erectus*, discovered at Trinil, Java, by Eugene Dubois in 1891. $\times \frac{1}{2}$ nat. size.

bone) which as an anatomist he at once recognized as that of an upright-walking creature. He became convinced, however, that all these specimens belonged to the same species—indeed he thought that they were parts of a single individual. He estimated that when the skull was complete its capacity must have been 908 cc. (*sic!*), whereas in man the cranial capacity rarely if ever fell below 1,000 cc.

Dubois' first scientific account of these important finds appeared in German[5] in 1894 under the title (translated) "*Pithecanthropus erectus, a Man-like Transitional Form from Java*". The generic name, *Pithecanthropus* (from the Greek πιθηκος ape ἀνθρωπος man) had already been used by the evolutionist Ernst Haeckel in 1866[6] for the hypothetical transition between ape and man, popularly known as the Missing Link. The specific name, *erectus*, referred of course to the inferred upright posture of the creature.

The publication of this paper by Dubois in 1894 naturally gave rise to considerable controversy. There were many points in dispute : did the skull-cap and the thigh-bone belong to the same creature or could the first be ape and the second human? Were they even contemporaneous? What was the geological age of the deposit from which they had been obtained : Pliocene or Pleistocene? One thing at least was certain, Dubois had discovered a skull more human than that of any known ape, and more ape-like than that of any known man.

Further discoveries in Java and in China after the first world war left no doubt that *Pithecanthropus* was an early stage in the evolution of man. Looking back one might count Dubois' discovery as the first concrete proof of man's evolution from an ape-like stock. But the absolute and relative dating of the Javanese material are still matters actively engaging attention.

Dubois at first[7] regarded the stratum containing the remains of *Pithecanthropus* as of Pleistocene age, but later[8] he stressed the difficulty of distinguishing between Tertiary and Quaternary faunas in the tropics, which were largely unaffected by the glaciations. After comparing the Trinil fauna with the fossil faunas in North-west India, he eventually came to the conclusion[9] that it was equivalent to that of the uppermost Siwalik Beds, then regarded as Upper Pliocene.

In the hope of obtaining more evidence about *Pithecanthropus*, particularly in regard to the vital question of its geological age, a German expedition under Frau Selenka visited Java in 1906 and made extensive excavations at Trinil.[10] Although more than 10,000 cubic feet of earth were moved, no further remains of " Java Man " were brought to light. The quantities of associated fossil fauna collected on this expedition helped towards a new assessment of the age of the deposits.

The Trinil beds are partly fluviatile, consisting of clays and sands deposited by the river, but also including quantities of volcanic ejectamenta, mainly ash and *lapilli*. The fossil bones occur in a conglomeratic ashy layer[11] two or three feet thick (Text-fig. 40) which appears to have been the result of a tumultuous flood following a volcanic eruption.[12]

The Trinil bone-bed, the horizon of *Pithecanthropus*, yielded remains of a rich mammalian fauna of Asiatic origin : deer, pigs, tapirs, hippopotamus, monkeys, carnivores, and—particularly important from the point of view of dating and correlation—the extinct elephant *Elephas hysudricus*, an advanced form of the elephantine *Stegodon*, and primitive wild cattle known as *Epileptobos*. Blankenhorn, reviewing the palaeontological evidence in 1911, concluded[13] that the Trinil beds should be ascribed to the " period of transition " marked in Europe by deposits with *Elephas meridionalis*, at that time still regarded by most geologists as Late Pliocene. His collaborator Julius Schuster, on the other hand, pointed out[14] that the fossil plants in a seam of clay in the upper part of the Trinil beds indicated a cooler and wetter climate than at present, which favoured correlation with an early Pleistocene glacial stage. Glacial conditions in high latitudes were probably

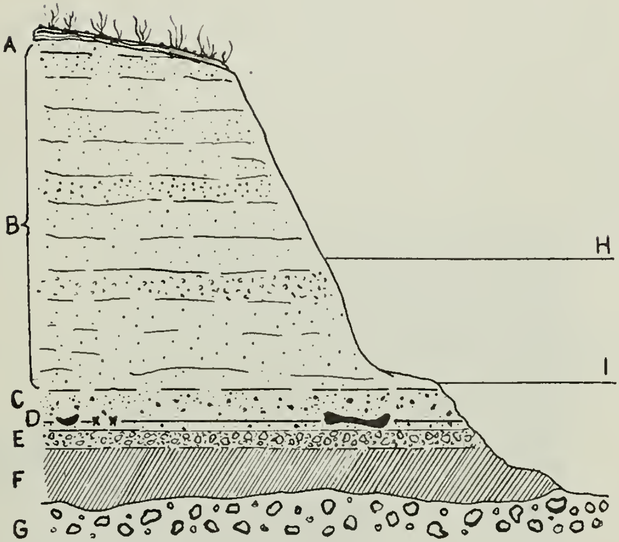



FIG. 40. Section of the deposits at the *Pithecanthropus* site at Trinil, based on drawing by Dubois.

coincident with wetter or " pluvial " conditions in the tropical and equatorial regions.

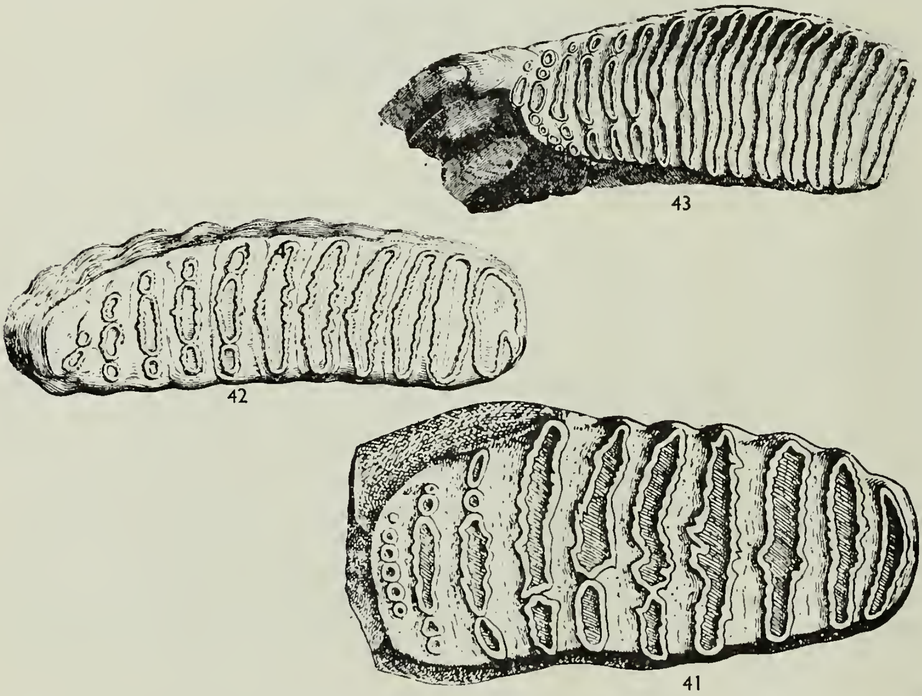
At about the same time as the members of the Selenka expedition were reporting their findings, the palaeontologist Emil Haug published a very far-sighted solution to the problem of where to draw the boundary between Pliocene and Pleistocene. The practice of defining the Pleistocene as commencing with glaciation was proving useless to geologists working on deposits possibly of this age in regions which had never been glaciated. Haug suggested[15] that the initial spread of true elephant (*Elephas*), true horse (*Equus*) and cattle (*Bos*) should be taken to mark the base of the Pleistocene. This involved including within the period those deposits termed Villafranchian in Europe which contained remains of *Elephas* (*Archidiskodon*) *meridionalis* or of the co-lateral species *Elephas planifrons*. Although the horse had not reached Java by the time of deposition of the Trinil beds, the presence of *Elephas* and *Epilepotobos* in these layers qualified them for inclusion in the Pleistocene according to Haug's definition, which was not, however, widely accepted until many years later.[16]

In a review of the evidence for the age of *Pithecanthropus* published in 1931, Van Es ascribed the Trinil beds to the Lower Pleistocene.[17] The modern practice of classifying the deposits of the Pleistocene period as Lower, Middle or Upper, developed during the second quarter of this century, but apparently without any published agreement as to how or where the boundaries should be drawn.[18] The species of elephant which successively predominated in Europe (Text-figs. 41–43) served as one of the bases for this subdivision as follows :

Upper Pleistocene : *Elephas* (*Mammuthus*) *primigenius* (mammoth).
Middle Pleistocene : *Elephas* (*Palaeoloxodon*) *antiquus*.
Lower Pleistocene : *Elephas* (*Archidiskodon*) *meridionalis*.

There is an overlap in the time ranges of these species but the time of first appearance of each serves to mark the base of a division. Attempts have been made to extend this system beyond Europe by correlation of equivalent or co-lateral species. Thus eastwards through Asia *Elephas meridionalis* gave place to *E. planifrons*. In recent years the recognition of *Elephas* (*P.*) *hysudricus* as equivalent to *E.* (*P.*) *namadicus* in the Indian Pleistocene, and that in turn as closely comparable with *E.* (*P.*) *antiquus* in Europe, has contributed to the modern classification of the Trinil beds as Middle Pleistocene.[19]

The next important discovery was made in Europe. Herr J. Rösch, owner of a sand pit at Mauer in the valley of the Neckar, 6½ miles south-east of Heidelberg, had been encouraged by Dr. Otto Schoetensack, geologist in that university, to



FIGS. 41–43. Penultimate lower molars of the three subgenera of *Elephas* which distinguish the main divisions of the Pleistocene.
FIG. 41. *Elephas* (*Archidiskodon*) *meridionalis* Nesti. *After Commont.* × ½ nat. size.
FIG. 42. *Elephas* (*Palaeoloxodon*) *antiquus* Falconer & Cautley. *After Falconer & Cautley.* × ½ nat. size.
FIG. 43. *Elephas* (*Mammuthus*) *primigenius* Blumenbach. *After E. Lartet.* × ⅓ nat. size.

take an interest in the fossil bones brought to light from time to time during the digging of the sand which was of early Pleistocene age. He had cherished the hope that one day remains of early man would be found. On October 21st 1907 his dream came true.[20] One of his workmen unearthed a massive human mandible, obviously fossil, just over 80 feet below the top surface of the deposits (which were worked in terraces), and about 3 feet above their base (Text-fig. 44). The discovery was witnessed by another workman and by a boy. Herr Rösch at once sent word of the discovery to Dr. Schoetensack, who visited the site on the following day.

The Heidelberg jaw (Plate 3) is remarkably complete and well preserved, although the crowns of four of the teeth on the left side adhered to pebbles in the deposit and

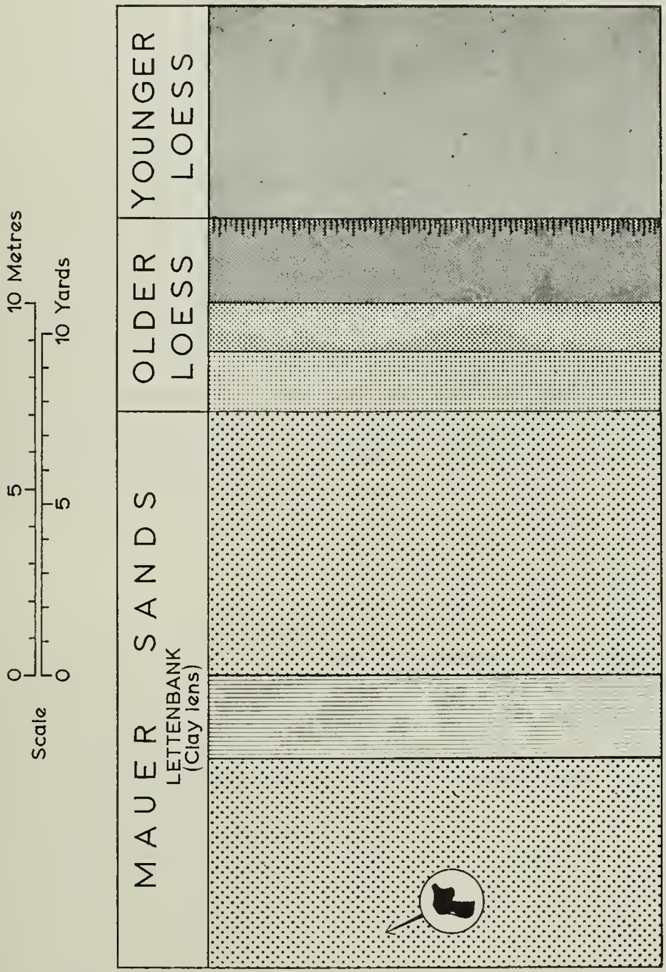



FIG. 44. Section of the Mauer sandpit, near Heidelberg. Scale drawing based on original photograph published by O. Schoetensack (1908).

were lost while it was being dug out. The bone itself, deep yellow in colour and speckled with small black dendrites, is obviously identical in preservation with the numerous fossil mammalian remains found in the Mauer Sands. The jaw gave rise to very little controversy, probably because it was such a thoroughly satisfactory find from many points of view: its stratigraphic position was beyond doubt; it required no restoration ; it was extremely " primitive " ; unlike the jaw of any living race of man, yet unquestionably human, thus agreeing with evolutionary theory without presenting any problem as to whether it should be classed with man or with apes ; and above all it was competently investigated by Schoetensack who lost no time in publishing a comprehensive monograph on the specimen and its geological age.[21]

The associated fauna, indicating a temperate climate and mainly woodland conditions, included *Elephas* (*Palaeoloxodon*) *antiquus*, *Rhinoceros* (*Dicerorhinus*) *etruscus*, *Sus* (pig), *Hippopotamus*, *Bison*, *Cervus elaphus* (red deer), *Equus*, *Trogontherium* (giant beaver), *Castor* (ordinary beaver), *Machairodus* (sabre-tooth cat) and *Ursus arvernensis* (Villafrancian bear).

We may recall that Neanderthal teeth were already known in association with *Elephas* (*Palaeoloxodon*) *antiquus* at Taubach in Eastern Germany, but the presence at Mauer of *Trogontherium*, *Dicerorhinus etruscus* and *Ursus arvernensis*, survivors of the Villafranchian fauna of Europe, indicated that the Heidelberg Man dated from much closer to the beginning of the Pleistocene. No stone artifacts were found in the Mauer Sands, but after comparison with the Pleistocene succession in Belgium, Rutot[22] concluded that the horizon of the jaw was earlier than that of the Strepyan and Mesvinian industries, then regarded as Pre-Chellean.

The great antiquity of the Heidelberg jaw was indicated not only by the associated fauna, but also by its stratigraphic position. The Mauer Sands, which were evidently laid down under temperate conditions, are overlain by loesses and loess-loams representing a succession of glacial and interglacial periods. Schoetensack recognized the following sequence :

Younger Loess : 19 feet
Older Loess : 17 feet
Mauer Sands : 43 feet.

Loesses are valuable for Pleistocene correlation because they were formed contemporaneously with glaciation, but are traceable for considerable distances beyond the glaciated region. These dust deposits accumulated under the intensely dry, windy conditions which widely prevailed during glacial stages on account of the anticyclone associated with an ice-sheet ; and in north-western Europe they generally contained a calcareous component. During the warmer and moister interglacial periods, when the surface became more thickly vegetated, soil acids percolating downwards gradually converted the loess into loam. Where the loess of one glacial stage overlies that of an earlier one, the junction between them is clearly marked by the zone of loamy weathering at the top of the older. It was soon recognized that the Younger Loess at Mauer was formed during the Last Glaciation, and the Older Loess during the Third or Riss. Thus the underlying sands were at least of Second Interglacial age, and probably older. Rutot[23] considered that a layer of sandy clay in the middle of the sands represented the Mindel glaciation, a correlation which placed the horizon of the jaw (found near the base of the sands) in the preceding or First Interglacial. Subsequent research showed that this was the correct dating of Heidelberg Man, but Rutot based it on wrong evidence for the sandy clay is merely a facies of the Mauer Sands, not indicating any climatic change.

When the geologist Soergel reinvestigated the sections in the Mauer sand-pit in 1927[24] he found that the Younger and Older Loesses were subdivisible by levels of loamy weathering which represented mild intervals (interstadials) within the main glacial stages. He also found evidence of a considerable break in the sequence between the Mauer Sands and the Older Loess of the Riss glaciation. The absence of glacial erratics from the gravel layers within the Mauer Sands has been cited[25] as evidence that these deposits of the ancient Neckar river were laid down before they received outwash from the first extensive glaciation, which was the Mindel. Thus, on the basis of stratigraphical geology there seemed little doubt that the Mauer Sands dated from a very early stage of the Pleistocene period. Yet there has been a conspicuous lack of agreement among authorities as to whether the horizon of Heidelberg Man should be counted as Lower Pleistocene, or as Middle Pleistocene. This is more a question of what label to attach to this stratigraphical level, than of doubt as to what level the sands represent (see below).

Professor F. E. Zeuner, following some earlier continental workers, drew the arbitrary line between Lower and Middle at the beginning of the " Great Interglacial " thus including both the Mindel and the Günz glaciations in the Lower Pleistocene.[26] This does not correspond with the classification now most widely adopted, that is to say the one based on Haug's proposal (p. 137) which lowered the base of the Lower Pleistocene to include the long preglacial stage known as Villafranchian, formerly classed as Upper Pliocene. The modern classification of the earlier part of the Pleistocene is therefore as follows :—

| | |
|---|---|
| Middle Pleistocene | Mindel-Riss interglacial<br>Mindel glaciation<br>Günz-Mindel interglacial |
| Lower Pleistocene | Günz glaciation[27]<br>Pre-Günz : warm preglacial stages interrupted by minor glacial advances. |

The stratigraphical position of the Mauer Sands is well attested by their mammalian fauna. This is fully interglacial in character, of a facies indicating a mixed-oak forest background, and broadly similar to the fauna of the Cromer Forest Bed, recognized by James Geikie as representing the First or Norfolkian Interglacial.

The faunal remains in the Mauer Sands all belong to a contemporaneous group, whereas the " Cromer Forest Bed fauna " appears to contain a mixture of faunas representing several time levels,[28] and consequently wide use of the term Cromerian as a faunal stage name needs reconsideration. When the Mauer fauna was compared with other early mammalian assemblages on the Continent its position in the sequence of Pleistocene stages became quite clear.[29] It is post-Villafranchian, and therefore no longer classed as Lower Pleistocene. Thus *Elephas meridionalis* (a species of the subgenus *Archidiskodon*) is absent from the Mauer assemblage while *Elephas antiquus* a species of the subgenus *Palaeoloxodon*, typical of the Middle Pleistocene, is present in considerable strength (forming 18 per cent. of the fauna),[30] although it is of a primitive form.[31]

The Mauer fauna is younger than the temperate steppe fauna of Mosbach near Mainz, which includes a subspecies of *E. meridionalis* and probably corresponds with the weak Günz glaciation in the Alps ; but it is older than the cool steppe fauna of the Süssenborn gravels in Thuringia which can be equated with the oncoming of the Mindel glaciation. The absence of the cave-hyaena, *Crocuta crocuta*, from the Mauer fauna indicates that it antedates the whole Mindel complex.[32]

Thus the sands which yielded the Heidelberg jaw are confidently regarded as belonging to the First or Günz-Mindel Interglacial, and not to a Mindel interstadial as suggested until recently by some authorities.

Anatomically among the most notable features of the Heidelberg jaw, are its massiveness and absence of chin. The side wings, known technically as the ascending rami, are only shallowly notched ; and they are exceptionally broad, thus providing an unusually large area for the attachment of the *masseter* muscles used in chewing. This last feature indicates that the lower jaw in this type of man was, as Sir Arthur Keith expressed it[33] " framed to serve the purpose of mastication ", whereas " the mandible of modern Man is modified to serve in speech ". Relative to the size of the jaw itself the teeth are rather small but very strongly implanted. Their roots are fused, a development which may be connected with powerful mastication. As in the lower jaw of Neanderthal men, the place of the tubercule in the inside of the chin region which in modern man serves for attachment of tongue muscles is occupied by a small pit.

Schoetensack referred the jaw to an extinct species of mankind, *Homo heidelbergensis*, which became regarded by many anthropologists as the precursor of *Homo neanderthalensis*. However, a number of authorities have questioned whether the species represented by this jaw should be placed in the same genus as the Neanderthal and modern species of man (i.e. in *Homo*). W. H. L. Duckworth,[34] for instance, said : " Would the Mauer jaw be appropriate to the cranium of *Pithecanthropus*? I believe an affirmative answer is justified ". The view is now widely held that Heidelberg Man was in all probability the European equivalent of *Pithecanthropus*, but until a cranium of the former is known generic identification must remain in doubt.

Historically it is interesting to read what Keith[35] had to say about " *Homo* " *heidelbergensis* in 1911 : " From the Heidelberg jaw ", he wrote, " we learn that the human mechanism of mastication was fully evolved at the beginning of the Pleistocene Period. The canine teeth which are so large and prominent in all forms of anthropoids have in the Heidelberg specimen subsided to the level of the neighbouring teeth in the dental series. We must assume that at one period in the evolution of Man the canines were prominent and pointed as in the anthropoids. . . . The retrogression of the canine teeth in the primitive human stock and the evolution from the anthropoid . . . must be sought for in the Pliocene period or even earlier."

It is clear from these remarks that the Pliocene ancestor of man was expected to have a more ape-like lower jaw than the early Pleistocene Man of Heidelberg. At about the same time that Keith was expressing this opinion, another anatomist, Elliot Smith,[36] had made out a strong case for believing that in the evolution of man " the brain led the way ". It was therefore not unreasonable to believe that the hypothetical ape-jawed ancestor living in the Pliocene period would have had a braincase that was manifestly human—indeed perhaps more human in appearance than the braincase of *Pithecanthropus* which was still regarded by some authorities at that time as an ape.[37]

It is not unlikely that against this background of ideas, the amateur archaeologist Charles Dawson began to entertain the hope that some of the ancient gravels in his own county of Sussex would one day yield relics of man's Pliocene ancestor. Already in 1899[38] he had noticed a patch of gravel at Piltdown near Fletching which he thought was a possible source of fossils. The gravel contained eoliths, supposed by some to be artifacts of Pliocene Man. Whether it was Dawson, or one of his acquaintances, who first thought that this would be an excellent finding-place for a fabricated " missing link " we may never know, but in due course this idea bore fruit in the form of " *Eoanthropus* ".

SECTION VI (Notes)


1 DUBOIS, E. 1889. On the need for an investigation into the existence of the Ice Age fauna in the Dutch East Indies, especially in Sumatra. *Natuurk. Tijdschr. Ned.-Ind.*, Batavia, **48** : 148–163. (In Dutch.)

2 For a general account of the Javanese discoveries see Koenigswald, G. H. R. von. 1956. *Meeting Prehistoric Man* : 20–39, 65–142. London.

3 Dubois first reported the Kedung Brubus and Trinil finds in the quarterly reports to the Mining Authority : *Verslagen van het Mijnwezen*, 4de Kwartaal, 1890 ; 3de Kwartaal, 1891 ; 4de Kwartaal, 1891 ; 3de Kwartaal, 1892 ; 4de Kwartaal, 1893.

4 Described by Lydekker, R. (1886 *Palaeont. indica.*, Calcutta (10) **4** : 2) as *Troglodytes sivalensis*, later referred to *Sivapithecus* Pilgrim (1915 New Siwalik Primates and their bearing on the Question of the Evolution of Man and the Anthropoidea. *Rec. Geol. Surv. India*, Calcutta, **45** : 1–74 (esp. p. 47).

5 DUBOIS, E. 1894. *Pithecanthropus erectus, eine menschenähnliche Übergangsform aus Java.* Batavia. Also in *Jaarb. Mijnw. Ned.-Oost-Ind.*, Buitenzorg, **1895** : 5–77.

6 HAECKEL, E. 1875. *History of Creation* : 3rd ed. 1883, : 271, 293. London.

7 DUBOIS, E. 1892. *Natuurk. Tijdschr. Ned.-Ind.*, Batavia, **51** : 93–100.

8 KOENIGSWALD, G. H. R. VON. 1956. *Meeting Prehistoric Man* : 38, 39. London.

9 DUBOIS, E. 1908. Das geologische Alter der Kendeng oder Trinilfauna. *Tijdschr. K. Ned. Aard. Genoot.*, Amsterdam, **25** : 1235–1270.

10 SELENKA, L. & BLANCKENHORN, M. 1911. *Die Pithecanthropus-Schichten auf Java.* Leipzig.

11 DUBOIS, E. 1896. On *Pithecanthropus erectus* : a transitional form between Man and Apes. *J. Anthrop. Inst.*, London, **25** : 240–255.

12 TERRA, H. DE. 1943. Pleistocene Geology and Early Man in Java. *Trans. Amer. Phil. Soc.*, Philadelphia (n.s.) **32** : 447–450.

13 BLANCKENHORN, M. *In* Selenka, L. & Blanckenhorn, M. 1911 : 264–265. See Note 10.

14 SCHUSTER, J. 1911. *In* Selenka, L. & Blanckenhorn, M. 1911 : 219, 256. See Note 10.

15 HAUG, E. 1911. *Traité de Géologie*, **2** : 1767. Paris. Haug pointed out that new types of Asiatic origin appeared abruptly in the Villafranchian stage : " ces immigrés sont les

genres *Elephas, Equus* et *Bos*. Leur introduction soudaine dans la faune européenne constitue un événement assez important pour justifier l'établissement d'une coupure de premier ordre. Aussi placerons-nous à la base du Quaternaire le Villafranchien ".

[16] The Pliocene-Pleistocene Boundary (ed. K. P. Oakley), *Rep. 18th Sess. Int. Géol. Congr.* (London, 1948), Pt. ix, 1950 : 6.

[17] Es, L. J. C. van. 1931. The Age of *Pithecanthropus* : 134–137. The Hague.

[18] Koenigswald, G. H. R. von. 1956. *Meeting Prehistoric Man*, London ; Hooijer, D. A. 1956. The lower boundary of the Pleistocene in Java and the age of *Pithecanthropus*. *Quaternaria*, Rome, **3** : 5–10.

[19] Hopwood, A. T. 1935. Fossil Elephants and Man. *Proc. Geol. Ass., Lond.*, **46** : 55. Soergel, W. 1913. *Elephas trogontherii* Pohlig und *Elephas antiquus* Falc. *Palaeontographica*, Stuttgart, **60** : 799.

[20] Keith, A. 1925. *The Antiquity of Man*, **1** : 319.

[21] Schoetensack, O. 1908. *Der Unterkiefer des Homo heidelbergensis : Ein Beitrag zur Palaeontologie des Menschen.* Leipzig.

[22] Rutot, A. 1909. Note sur la Mâchoire humaine de Mauer. *Bull. Soc. Belge Géol. Pal. Hydr.*, Bruxelles, **22** : 117–132. Referred the Lower Mauer Sands, which yielded the jaw, to the horizon of the " Mafflian " flake industry, which he then regarded as Pre-Chellean but later equated with Chellean (see Sollas, W. S. 1924. *Ancient Hunters* : 156, 174. 3rd ed. London).

[23] Rutot, A. (1909 : 131) termed the clayey layer between the Lower and Upper Mauer Sands the *Lettenbank* and equated it with the *Glaise moséene* in Belgium which was then considered to be contemporaneous with a phase of the Mindel glaciation.

[24] Soergel, W. 1928. Das geologische Alter des *Homo heidelbergensis*. *Paläont. Z.*, Berlin, **10** : 217–233. See also Zeuner, F. E. 1958. *Dating the Past* : 156. 4th ed. London.

[25] Howell, F. C. 1960. European and Northwest African Middle Pleistocene Hominids. *Curr. Anthrop.*, London, **1** : 199–202.

[26] Zeuner, F. E. 1958. *Dating the Past* : 118. 4th ed. London.

[27] Oakley, K. P. 1961. The Günz Glaciation. *New Scientist*, London, **11** : 246. A few authors count the Günz glacial stages as the base of the Middle Pleistocene, but Günz-stage deposits on the south side of the Alps contain Villafranchian fauna according to Nangeroni (1950) and Venzo (1955) quoted by Flint, R. F. 1957. *Glacial and Pleistocene Geology* : 384–387. London.

[28] Azzaroli, A. 1953. The Deer of the Weybourne Crag and Forest Bed of Norfolk. *Bull. Brit. Mus.* (*Nat. Hist.*) *Geol.*, London, **2** : 90.

[29] Howell, F. C. 1960. European and Northwest African Middle Pleistocene Hominids. *Curr. Anthrop.*, London, **1** : 199–202.

[30] Soergel, W. 1923. Die diluvialen Säugetiere Badens I. *Mitt. bad. geol. Landesanst.*, Heidelberg, **9** : 1–254 (esp. p. 173).

[31] Adam, K. D. 1961. Die Bedeutung der Pleistozänen Säugetier-Faunen Mitteleuropas für die Geschichte des Eiszeitalters. *Stuttgart. Beitr. Naturk.*, **78.**

[32] In contrast the Corton beds, which probably represent a Mindel interstadial, do contain teeth of *Crocuta crocuta*. Kurtén, B. 1956. The status and affinities of *Hyaena sinensis* Owen and *Hyaena ultima* Matsumoto. *Amer. Mus. Novit.*, New York, 1764 : 41.

[33] Keith, A. 1911. *Ancient Types of Man* : 83. London.

[34] Duckworth, W. H. L. 1912. *Prehistoric Man* : 14. Cambridge.

[35] Keith, A. 1911 : 84.

[36] Smith, G. Elliot. 1913. *Rep. Brit. Ass.*, **1912** : 594–598 ; 1927. *Essays on the Evolution of Man* : 71. 2nd ed. Oxford.

[37] Smith, G. Elliot. 1927 : 71.

[38] Dawson, C. 1913. The Piltdown Skull. *Hastings Nat.*, **2** : 75–76.

## VII. PRINCIPLES OF RELATIVE AND ABSOLUTE DATING

The chronological placing of fossils, whether they be early men or lower organisms, is fundamentally important for understanding their evolutionary relationships. Several distinct kinds of dating are involved. *Relative dating* places an event with reference to some other event in a time-sequence. A fossil or a deposit can be regarded as representing an " event ": the interval of time when it was alive or being formed. In the relative dating of fossils reference is generally made to irregularly spaced, arbitrarily chosen events, which are geological, palaeontological or archaeological. For example, in Europe the spread of *Elephas*, *Equus* and *Bos* has been chosen to mark the beginning of Pleistocene time, the ending of glacial conditions to mark the beginning of Recent, Post-Glacial or Holocene time, and the change from hunting to farming economy to mark the beginning of the Neolithic period. In the sense that none of these events occurred everywhere simultaneously, the dating of a specimen as Basal Pleistocene, Early Post-Glacial or Early Neolithic does not necessarily imply exact contemporaneity with specimens similarly dated in other parts of the world.

All dating is in a sense " relative ", but when it relates an event to a regular astronomical event-series, particularly the passage of years or siderial time, it is commonly called *absolute dating*. Thus, to date a skull as " Early Neolithic " is to place it in a sequence of archaeologically determined events ; to date it as 6000 B.C. is to date it absolutely. Unfortunately the use of the term " absolute dating " as synonymous with " dating in years " has blunted the meaning of the word absolute, for it makes no distinction between referring an event to a span of years and referring it to a particular instant in time. Some authors[1] have preferred to use the term " absolute " age with reference to contemporaneity between one deposit or species and another. For instance, if two deposits in widely separated regions were proved to be contemporaneous without being dated in years they could be said to be of the same absolute age. On the other hand, two deposits both dated as being " between 20,000 and 25,000 years old " (so-called absolute dating) might not be contemporaneous. In such cases relative dating may be more informative.

To know the correct time sequence of the fossil remains of man and his ancestors is basic to interpreting their significance ; but it is equally important from the point of view of understanding evolutionary process to obtain a measure of how much time separates one form from another. We are therefore concerned with two main classes of dating :

*Relative Dating :* the stratigraphical or archaeological age of a specimen or formation.

*Chronometric Dating* (hitherto called Absolute Dating) :[2] the age of a specimen or formation measured in years.

In practice there are several kinds of relative dating, each depending on a different range of evidence. When a human skull, for example, is dug up in some ancient deposit, those concerned with the discovery usually enquire at once : " Is it reliably dated ?" The first question to be settled is whether the specimen is contemporaneous with the deposit in which it was found, or whether it has been intrusively buried, or whether (as sometimes happens) it has been derived from some older formation and redeposited. This primary dating, the age-relation of a specimen to its containing deposit and to the associated finds, may be termed for convenience R.1 or first-order relative dating. If the specimen is a bone (or tooth) determination of its chemical composition in comparison with that of other bones of known stratigraphical age in the same deposit is a valuable means of establishing whether it is contemporaneous, intrusive or derived, for the chemical composition of buried bones changes in course of time. The analytical methods of dating bones, including fluorine analysis, nitrogen analysis and radiometric assay,[3] are mainly used for R.1 dating which is particularly important in connection with supposedly fossil human remains because of man's long-established habit of burying the dead.

When a scientific excavator discovers human remains, one of his first concerns naturally is to look for evidence showing whether they were artificially interred, or whether they were deposited or incorporated in some way during the accumulation of the containing deposit ; but the evidence in this respect is sometimes rather unclear. It may be lacking altogether if the human remains were removed from the ground in the absence of an experienced excavator, or if they were discovered in days before scientific methods of archaeological excavation had been introduced. Consequently, analytical methods of confirming or establishing the R.1 dating, that is to say whether human bones from ancient deposits are contemporaneous or non-contemporaneous with bones of known stratigraphical age from the same site, are useful both as a routine procedure and as a means of re-evaluating some of the early discoveries.

We may recall that it was the R.1 dating that was in doubt in all the following discoveries of possibly early remains of *Homo sapiens* :

Gailenreuth (1771) : Were the human bones contemporaneous with the associated cave-bear? (p. 92).

Paviland (1823) : Was the human skeleton contemporaneous with the associated mammoth remains, or a later burial? (p. 89, 106).

Grotte de Bize (1830) : Were the human bones contemporaneous with the associated extinct animals? (p. 91).

Aurignac (1852) : Were any of the human bones contemporaneous with the nearby Upper Palaeolithic fauna, or did they all belong to the superimposed burials of Neolithic age ? (p.106).

Moulin-Quignon (1863) : Was the human jawbone contemporaneous with the high-terrace gravel (containing " Chellean " *haches* or hand-axes) in which it was found, or was it a later implantation ? (p. 111ff).

Calaveras (1866) : Was the human skull contemporaneous with the Pliocene bone-bed in which it was allegedly found, or had it been recently implanted ? (p. 120f).

Foxhall (1855) : Was the human jawbone contemporaneous with the " Pliocene " (now classed as Lower Pleistocene) marine formation in which it was embedded, or was it part of a later burial ? (p. 118f).

Cro-Magnon (1868) : During the last century a few authorities doubted whether the interments in this cave were contemporaneous with the closely associated Upper Palaeolithic fauna, and suggested that they were early *post*-Palaeolithic (p. 123).

Castenedolo (1880, following an unpublished find of 1860) : Were the four skeletons contemporaneous with the Pliocene marine clay in which they were found (a Pliocene shipwreck was seriously suggested !) or were they in Post-Pliocene graves ? (p. 118).

Galley Hill (1888) : Was the human skeleton contemporaneous with the Middle Pleistocene gravel (containing Acheulian hand-axes) in which it was found, or was it an intrusive burial of much later date ? (p. 131).

In many of the other discoveries of early human or pre-human remains which we have reviewed there was no reason to doubt their contemporaneity with the deposit in which they were found but the stratigraphical or archaeological age of that deposit constituted a problem. The stage in the local stratigraphical sequence to which the containing deposit (or contemporaneous fauna or culture) is referable may be called the *R.2 dating* of a specimen. The inferred position of that stage in terms of world or wider-scale stratigraphy or culture sequence may be called *R.3 dating*. The distinction between R.2 and R.3 dating is rather arbitrary, but the former is usually based on fact, the latter on inference. There are of course some cases where R.2 dating and R.3 dating are synonymous. The following examples serve to illustrate the distinction between the various orders of relative dating :

| | R.1* | R.2 | R.3 |
|---|---|---|---|
| Engis I skull (1830) | *c.* | " Cold " Mousterian | Würm I |
| Engis II skull (1830) | *c.* | Aurignacian | Würm interstadial |
| Neanderthal skeleton (1856) | *c.*? | No direct evidence | No direct evidence |
| Cro-Magnon skeletons (1868) | *a.c.* | Aurignacian | Würm |
| Galley Hill skeleton (1888) | *i.* | Post-Swanscombe Middle Gravels | Post-Pleistocene or End-Pleistocene? |
| Gibraltar I skull (1848) | *c.*? | No direct evidence | No direct evidence |
| Gibraltar II skull (1926) | *c.* | Upper Mousterian | Würm |
| Spy skeletons (1886) | *a.c.* | " Cold " Mousterian | Würm I |
| Trinil skull (1891) | *c.* | Trinil Beds | Middle Pleistocene |
| Taubach tooth (1887) | *c.* | " Warm " Mousterian | Riss-Würm |
| Heidelberg jaw (1907) | *c.* | Mauer Sands | Günz-Mindel |
| Weimar-Ehringsdorf skeletons (1908) | *c.* | " Warm " Mousterian | Riss-Würm |

* Four R.1 categories are recognized :

*c.* —contemporaneous with deposit

*a.c.*—approximately contemporaneous, e.g. Upper Palaeolithic interment in an Upper Palaeolithic deposit.

*i.* —intrusive burial of much later date than the deposit.

*d.* —derived from an older formation and redeposited.

When a fossil bone or tooth (or indeed any fossil) is found in isolation, unaccompanied by other organic remains serving to establish the R.2 or R.3 age, it can sometimes be dated by its form or morphology. This method of relative dating (which elsewhere I have termed R.4 dating) is reliable in some groups of fossils where the time-spans of the genera and species are relatively short and well known, but in other groups, particularly rare groups, it is very unreliable. It does not allow for unsuspected survivals. For example, before the discovery of a living Coelacanth in 1938 any new fossil member of this group in rock of unknown age would have been dated morphologically as " unquestionably Cretaceous or earlier ", whereas in fact, as we now know, it might be Tertiary or even Quaternary. Morphological dating of fossil Primates (the group which includes man) has also proved unreliable, but it will no doubt become less so with the increase of our knowledge of the group. Few human palaeontologists would seriously question the correctness of inferring that the Neanderthal and Gibraltar skulls were of Upper Pleistocene age in view of their detailed similarity to the well-dated skulls of Spy, Le Moustier and elsewhere in Europe.

Morphological evidence is usually taken into consideration with other evidence bearing on the antiquity of fossil human remains of doubtful antiquity. Thus if a human skull is found in any early Pleistocene deposit and fails to pass any of the analytical tests for antiquity, the fact of its being indistinguishable from *Homo sapiens* would be regarded by most anthropologists as in keeping with the results of the tests ; whereas if a skull found in similar circumstances were morphologically " archaic ", negative evidence of antiquity would be less convincing.

Establishing the R.2 and probable R.3 ages of human remains depends on the application of the usual methods of stratigraphical geology and archaeology : observation of the stratification of the site where the remains have been found, noting any associated fauna, plant remains and artifacts, and comparing these with the contents of underlying and overlying deposits ; and eventually comparing the sequence with that at other sites further afield. The modern excavator pays particular attention to collecting shells and charcoal from the deposits under investigation, because these are not only likely to provide evidence of the climate prevailing when a deposit was being formed, but if found in sufficient quantities these materials can be chronometrically dated by the radiocarbon method. The excavator also usually preserves samples of the deposits for mineral- and pollen-grain analysis, techniques which provide valuable evidence for relative dating of human remains at some sites.

In many parts of the world the sequence of land faunas through Tertiary and Quaternary times has been worked out in some detail, so that if a large assemblage of contemporaneous mammalian remains is found in association with a fossil human skeleton, or part of a skeleton, its stratigraphical age (R.2 or R.3 dating) is fairly easily determined within certain limits. Fossil invertebrates are also useful for this type of dating, but they are less useful than vertebrate material because contemporaneity cannot be established by analysis. Assemblages of molluscan shells sometimes provide valuable indications of the age of lake beds, river beds and aeolian or other terrestrial deposits. Land and freshwater mollusca are fairly sensitive climatic indicators, and therefore may show whether a deposit is periglacial, interglacial, interstadial or post-glacial. Many of the species have restricted time-ranges (either locally or universally). To mention one example : the land snail *Pomatias elegans* was excessively rare in Britain before Post-Glacial times, and therefore the discovery that it was abundantly associated with the skeleton of Halling Man led to a revision of the dating of those remains.[4]

In discussing the relative dating of fossil human remains in any detail, it is necessary to be familiar with current terms and methods of classifying and correlating Quaternary deposits.

The " Absolute " or Chronometric dating of early human remains or other fossil bones is of four main types :

*A*.1 : direct determination of the age of the specimen itself from internal evidence ; for example by measuring the carbon-14 radioactivity of a sample of the bone.

*A*.2 : direct determination of the age of the source deposit ; for example by measuring the potassium–argon ratio if the deposit is potassic, or by measuring the carbon-14 radioactivity of associated bones, shells or charcoal, or of peaty material from the deposit which contained the specimen in question.

*A*.3 : the age of a specimen in years inferred by correlation of the source bed (or its horizon) with a deposit whose actual age has been determined.

*A*.4 : the age in years inferred from some theoretical consideration; for example dates obtained by expressing the local geological sequence in terms of climatic fluctuations, and matching these with the curve of past insolation as calculated by Milankovitch (the Absolute Chronology of Zeuner).[5] A more reliable form of A.4 dating recently introduced is the matching of climatic fluctuations in the Pleistocene sequences on land with marine palaeo-temperature changes recorded in ocean bed cores, and dating key layers of sediment in these cores by analysis of their content of uranium daughter elements.

It will be obvious that the validity of A.2, A.3 or A.4 dating of a specimen is conditional on the contemporaneity of the specimen with the containing deposit (i.e. the R.1 dating) being assured. Recent studies have emphasized that attempts at chronometric dating (excluding the A.1 type) are really a waste of time unless the R.1 dating has been established beyond doubt. This is illustrated by a list of the recorded datings of the Piltdown cranium :

1935 attempt at R.1 dating : " Derived from a somewhat older deposit ".[6] Consequent A.4 dating : *c.* 500,000 years.

1949 revised R.1 dating : " Contemporaneous with latest rearrangement of the deposit ".[7] Consequent A.4 dating : *c.* 50,000 years.

1953–4 corrected R.1 dating : " Recently implanted " [after being brought from some other site].
Attempted A.4 dating based on preservation of the bone : " Perhaps two or three thousand years old ".[8]

1959 C14 measurement gave chronometric age of the bone (A.1 dating) as : " A few centuries old ".[9]

The framework of relative chronology for Pleistocene deposits in Europe, Asia and Africa has become more dependable in recent years as a result of key points being dated chronometrically. Already by 1957 more than 120 samples of Upper Pleistocene deposits in Europe had been dated by the carbon-14 method [10] (limited to the last 60,000 years). Since 1958 the potassium–argon method of chronometric dating[11] has been applied successfully to numerous Lower and Middle Pleistocene volcanic deposits in Africa, Asia, Europe and America. Thus in the future, so long as their relative ages (R.1, R.2, and R.3) are well established, the majority of fossil human remains will be quite reliably dated in years by the A.3 procedure, and in many cases even more closely by the A.2 procedure.[12]

In order to complete this review of the history of human palaeontology, the following annotated table gives the modern chronometric (" absolute ") dating of those fossil men whose relative dating has been outlined on p. 147.

| | |
|---|---|
| Engis I skull. 45–70,000 years B.P. | *A*.3 *dating.* Cold Mousterian[13] judged to be in this time bracket on basis of chronometric dating of deposits of Early Würm stage. |
| Engis II skull. *c.* 30,000 years B.P. | *A*.3 *dating.* Aurignacian[14] *s.s.* II dated by C14 at La Quina as 31,000 years B.P. |
| Neanderthal skeleton. 35–70,000 years B.P. (?) | *A*.4 *dating.* No associated fauna or artifacts.[15] On *hypothetical* basis of morphology, this type specimen is presumed to be one of the later members of the Neanderthal group ; if so, Early Würm or Göttweiger Interstadial in age. |
| Cro-Magnon skeleton. *c.* 30,000 years B.P. | *A*.3 *dating.* Aurignacian *s.s.* i.e. dating on same basis[16] as Engis II skull. |
| Galley Hill skeleton. 3,310 ± 150 years B.P. (1960). | *A*.1 *dating.* Fragments of the humeri were directly dated by C14.[17] |
| Gibraltar I skull. 45–70,000 years B.P. | *A*.3 *dating.* Mousterian deposits in caves at Gibraltar judged to date from Early Würm time. Cf. Engis I skull. |
| Gibraltar II skull. > 30,000 years B.P. (probably *c.* 50,000). | *A*.2/3 *dating.* Small fragment of charcoal from Upper Mousterian layer at Gib. II site showed no measurable activity (> 30,000 years).[18] Charcoal from about same horizon at nearby site gave C14 age of 48,000 years B.P. (1959).[19] |
| Spy skeletons. 45–70,000 years B.P. | *A*.3 *dating.* Same basis as Engis I and Gibraltar I.[20] |
| Trinil skull. > 500,000 years B.P. | *A*.3 *dating.* Potassium–argon age of tektites associated with beds containing Trinil fauna.[21] |
| Taubach teeth. 60–120,000 years B.P.? | *A*.3 *dating* Riss-Würm interglacial[22] deposits, as stratigraphically dated by fauna; same age as those of Ehringsdorf (see below). |
| Heidelberg jaw. > 400,000 years B.P. | *A*.4 *dating* Potassium–argon age of volcanic tuffs (*c.* 400,000 B.P.)[23] linked with Rhine terrace post-dating Mauer Sands, Heidelberg. |
| Weimar-Ehringsdorf skeletons. 60–120,000 years B.P. | *A*.2 *dating.* Ratio of uranium daughter elements thorium–protoactinium in interbedded tufa or travertine indicated an age within this bracket.[24] This agrees with the Early Neanderthalers of Taubach and Ehringsdorf being of Riss-Würm age. |

SECTION VII (Notes)

[1] Ewer, R. F. 1956. The Fossil Carnivores of the Transvaal Caves : Two New Viverrids, together with some general considerations. *Proc. Zool. Soc. Lond.*, **126** : 259–274 (esp. p. 271).

[2] Oakley, K. P. 1953. Dating Human Fossil Remains. *In* Kroeber, A. L. *Anthropology Today* : 43–56. Chicago University Press.
Eight types of dating were distinguished as in the present work ; "Absolute" (in the sense now called Chronometric) : A.1, A.2, A.3, A.4 ; Relative : R.1, R.2, R.3, and R.4.

[3] Oakley, K. P. 1963. Analytical Methods of Dating Bone. *In* Brothwell, D. & Higgs, E. S. *Science in Archaeology* : 24–34. London.
For practical details of these tests see Oakley, K. P. 1963. Fluorine, Uranium and Nitrogen Dating of Bone. In *The Scientist and Archaeology*. Ed. E. Pyddoke. London.

[4] Oakley, K. P. 1963. Note on the antiquity of Halling Man. *In* Kerney, M. P. Late Glacial deposits on the Chalk of Southeast England. *Phil. Trans. Roy. Soc. Lond.*, ser. B, **246** : 250–251.

[5] Zeuner, F. E. 1958. *Dating the Past* : 110. 4th ed. London.

[6] Hopwood, A. T. 1935. Fossil Elephants and Man. *Proc. Geol. Ass. Lond.*, **46** : 47–50.

[7] Oakley, K. P. 1950. On the fluorine test for determining the relative antiquity of fossil bones. *Quart. J. Geol. Soc. Lond.*, **106** : iii. The estimate of 50,000 years appeared in *The Times*, Sept. 6, 1949, the following preliminary report of the results of the fluorine test.

[8] Oakley, K. P. 1954. Solving the Piltdown Problem. *Arch. News Letter*, London, **5** : 125.

[9] This carbon-14 dating of a sample of the Piltdown cranium was undertaken in 1959 by the late Professor Hl. de Vries. See Vries, Hl. de & Oakley, K. P. 1959. Radiocarbon Dating of the Piltdown Skull and Jaw. *Nature, Lond.*, **184** : 224–226.

[10] Libby, W. F. 1955. Radiocarbon Dating. 2nd ed. Chicago. For application of carbon-14 dates to Upper Pleistocene chronology see Gross, H. 1958. *Eiszalter u. Gegenwart*, **9** : 155–187.

[11] Evernden, J. F., Curtis, G. H. & Kistler, R. 1958. Potassium-Argon dating of Pleistocene Volcanics. *Quaternaria*, Rome, **4** (1957) : 13–17.

[12] Thus for example the East African australopithecine "*Zinjanthropus*" has been dated chronometrically by applying the potassium-argon method to the deposit in which it was embedded. See Leakey, L. S. B., Evernden, J. F. & Curtis, G. H. 1961. *Nature, Lond.*, **191** : 478–479. The validity of the date obtained has been widely debated, but it is agreed to be of the order of magnitude of one million years.

[13] Twiesselmann, F. 1952. *In* Catalogue des Hommes Fossiles. *C. R. XIXe Congr. Géol. Int.*, (5) Algers : 37, Engis I.

[14] Twiesselmann, F. 1952 : Engis II.

[15] Gieseler, W. 1952. *In* Catalogue des Hommes Fossiles. *C. R. XIXe Congr. Géol. Int.*, Algers (5) : 19–20. See also Campbell, B. 1956. *Man*, London, **56** : 156–158, 171–173.

[16] Vallois, H. 1952. *In* Catalogue des Hommes Fossiles. *C. R. XIXe Congr. Géol. Int.*, Algers (5) : 74. "Aurignacian (niveau des pointes à base fendue)".

[17] Barker, H. & Mackey, J. 1961. British Museum Radiocarbon Measurements III. *Radiocarbon*, London, **3** : 41.

[18] Vogel, J. C. to Oakley, K. P. *in lit.* Jan. 8, 1962.

[19] Charcoal from Upper Mousterian Layer G in Gorham's cave, Gibraltar, was radiocarbon dated by the late Professor H. de Vries in 1958 as *c.* 48,000 years old.

[20] Twiesselmann, F. 1952. *In* Catalogue des Hommes Fossiles. *C. R. XIXe Congr. Géol. Int.*, Algers (5) : 99.

[21] Koenigswald, G. H. R. von. 1962. Das absolute Alter des *Pithecanthropus erectus* Dubois. *Evolution und Hominisation* : 112–119 (esp. p. 117). Ed. G. Kurth. Stuttgart.

[22] Gieseler, W. 1952. *In* Catalogue des Hommes Fossiles. *C. R. XIXe Congr. Géol. Int.*, Algers (5) : 26.

[23] EVERNDEN, J. F., CURTIS, G. H. & KISTLER, R. 1958. Potassium-Argon dating of Pleistocene Volcanics. *Quaternaria*, Rome, **4** (1957) : 13–17.

The dated mineral, sanidine, came from the Laacher See tuffs, judged to be of Mindel II or Mindel I/II interstadial age, as they contributed to the Lower Main Terrace of the Rhine which is generally equated with Mindel II.

[24] ROSHOLT, J. N. & ANTAL, P. S. 1963. Evaluation of the $Pa^{231}/U\text{-}Th^{230}/U$ method for dating Pleistocene carbonate rocks. *U.S. Geol. Surv. Prof. Pap.*, Washington, **450** E : 108–111.

# VIII INDEX

The raised numbers in parentheses refer to the notes listed at the end of each section.

## PLATE I

The Gibraltar I Skull. $\times \frac{1}{3}$ nat. size. Brit. Mus. (Nat. Hist.) ; Royal College of Surgeons' Collection F.C.2787.

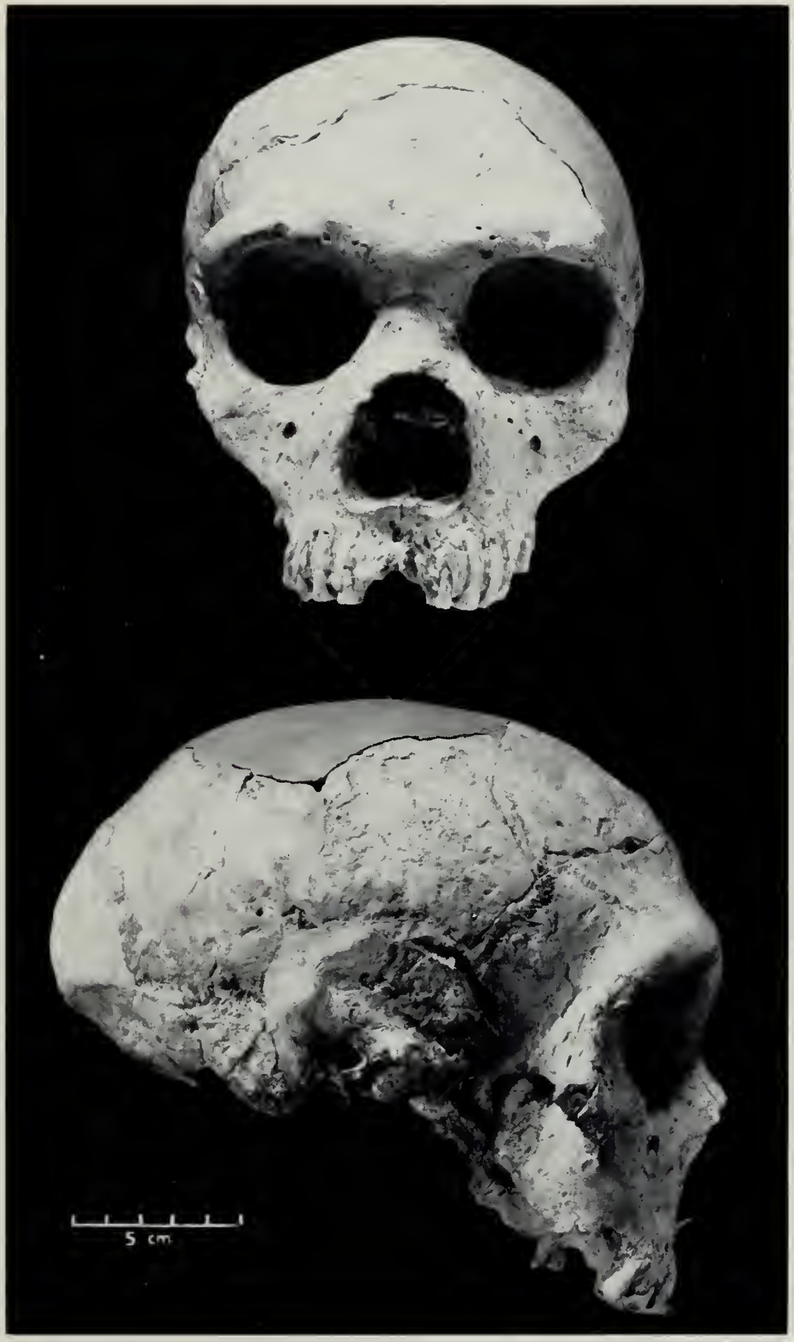

5 cm

PLATE 2

Cro-Magnon I Skull ("Old Man"). $\times \frac{1}{3}$ nat. size. Musée de l'Homme, Paris. *After Quatrefages & Hamy.*

PLATE 3

Heidelberg mandible. Two aspects. $\times \frac{1}{3}$ nat. size. Heidelberg University, Germany.
*After Schoetensack.*